Board of Scientific Advice for India.

Annual Reports

1920-21 to 1922-23

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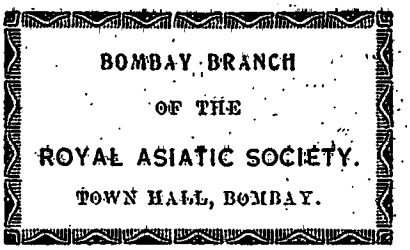

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Board of Scientific Advice for India

ANNUAL REPORT

FOR THE YEAR

1920-21 to 1922-23

26/15/9

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1922

Price As. 12.

Board of Scientific Advice for India

ANNUAL REPORT

FOR THE YEAR 1920-21

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SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1922

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CONTENTS.

		PAGE.
I.—Proceedings of the Board		1
I.—Annual Report—		
APPLIED CHEMISTRY—		
I.—*Agricultural*	F. J. Warth, M.Sc.	2
II.—*Forest*	J. L. Simonsen, Ph.D.	6
ASTRONOMY, METEOROLOGY, TERRESTRIAL MAGNETISM	G. T. Walker, C.S.I., M.A., Sc.D., F.R.S.	8
GEOLOGY	E. H. Pascoe, M.A., D.Sc., F.G.S.	13
GEODESY	Lieutenant-Colonel H. McC. Cowie, R.E.	15
GEODETIC RESEARCH AT DEHRA DUN	J. de. Graaff Hunter, M.A., Sc.D. F. Inst. P.	18
BOTANY—		
I.—*Botanical Survey*	Lieutenant-Colonel A. T. Gage, I.M.S.	23
II.—*Economic Botany*—		
I.—*Agricultural*	A. Howard, C.I.E., M.A., A.R.C.S., F.L.S.	25
II.—*Forest*	R. S. Hole, C.I.E., F.C.H.	29
III.—*Mycology and Plant Pathology.*	F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S.	32
AGRICULTURAL BACTERIOLOGY	J. H. Walton, M.A., M.Sc.	36
FORESTRY—		
I.—*Silviculture*	S. H. Howard, B.A.	38
II.—*Economic Forest Products*	R. S. Pearson, C.I.E., I.F.S.	41
ZOOLOGY—		
I.—*General Zoology and Physical Anthropology.*	S. W. Kemp, D.Sc., F.A.S.B.	45
II.—*Economic Entomology*—		
I.—*Agricultural*	T. B. Fletcher, R.N., F.L.S., F.E.S., F.Z.S.	47
II.—*Forest*	C. F. C. Beeson, M.A., I.F.S., F.E.S.	51
VETERINARY SCIENCE	W. A. Pool, M.R.C.V.S.	53
MEDICAL RESEARCH	The Hon'ble Major-General Sir W. R. Edwards, K.C.I.E., C.B., C.M.G., K.H.P., M.D., I.M.S., F.R.C.S.E.	55

Annual Report of the Board of Scientific Advice for India, 1920-21.

SUMMARY OF PROCEEDINGS.

Fortieth meeting held at Delhi on the 28th November 1921.

The programmes of the various departments for 1921-22 and the draft Annual Report of the Board for 1920-21 were considered and accepted.

The Board discussed the Report of the Libraries Sub-committee on the provision of scientific libraries in India and on the perishing of paper in India. It was resolved that the Education Department should be asked to publish the catalogue of scientific periodicals available in India outside Calcutta as soon as possible and that the Libraries Sub-committee should prepare a list of scientific periodicals suitable for libraries in India; that if the catalogue and the list were ready in time the Education Department should be asked to nominate a representative specially to attend the next meeting of the Board to consider the action to be taken. In respect of the perishing of paper the Board referred the question to a Sub-committee to consider what action could be taken on the Report issued by the Indian Institute of Science and to report to the Board before the next meeting.

The proposal made by the Agricultural Adviser to the Government of India to abolish the sections of the Annual Report of the Board for which the Agricultural Department was responsible and a proposal by the Inspector-General of Forests that the Annual Progress Report of Forest Research work in India should be accepted by the Board for inclusion in its Annual Report instead of the special contributions hitherto supplied were discussed. The Board came to the conclusion that the present practice of compiling the Annual Report of the Board should be continued. They regretted they were unable to accept the suggestion of the Inspector-General of Forests, and expressed the opinion that the preparation of a special triennial Report or Review of all scientific work in India for the Board should not be attempted.

The Board then considered the qualifications of a representative of the Education Department to be nominated as a member of the Board. It was resolved that while the Board would prefer the representative of the Education Department to possess scientific qualifications, any nomination that the Education Department desired to make would be welcomed.

A proposal for the establishment of a Marine Biological Station at Port Blair and Andaman Islands was considered. The scheme was referred to a Sub-committee for report before the next meeting of the Board.

APPLIED CHEMISTRY

PART I.—AGRICULTURAL CHEMISTRY

BY

F. J. WARTH, M.Sc.

Officiating Imperial Agricultural Chemist.

SOILS.

Soil Surveys.—In Madras the survey of the Periyar tract has been almost completed.

The traverse survey which is being carried out by Somers Taylor in Behar has been extended to the foot-hills in Santhal Parganas. The deficiency of P_2O_5 already noted was found to be more marked as the hills were approached.

In the Central Provinces, a survey of the lateritic Bhatta soils has been completed by Plymen.

Soil Moisture.—In the Punjab, Wilsdon has continued his work on soil moisture movement. Interesting measurements relating to percolation from flowing water channels have been obtained. It was found that the vertical movement is much greater than the lateral.

Soil Nitrogen.—Somers Taylor has noted marked seasonal variation of Organic Nitrogen in certain Behar soils. The study of this important observation is being continued.

Soil Acidity.—Harler has shown that the acidity and toxicity of Assam tea soils are related to Alumina in solution. The toxicity of the soil may be reduced by treatment with super, potash salts or lime.

Soil gases.—Mukherji has continued his work on formation of CO_2 in grassed and fallow plots at Pusa. It is only during the rainy season that very marked increase in CO_2 on the grassed plots occurs.

Experimental area, Pusa.—Sen has carried out preliminary experiments which show that some marked variations in soil composition occasionally occur. Crop growth can be correlated with these differences.

The crops are however patchy also in places where soil composition is uniform. The factors affecting growth in such areas is under investigation.

MANURES AND MANURING.

The important experiments on availability of ground phosphate when composted with green manure have been continued in Madras.

The relative efficiency of super and ground phosphate in combination with green manure has been tested in Behar. For light phosphate dressings the efficiency of the two manures was practically identical. The ground phosphate however when used in larger amounts causes no further improvement such as is obtained with super.

In the Punjab the value of green manuring on sandy soils as a means of retaining soil moisture has been clearly shown.

Coleman has carried out experiments on the availability of nitrogenous manures on the Red Mysore soil. Am_2SO_4 was generally superior to $NaNO_3$. The latter, it was shown, had a deleterious effect on the soil texture. Green manures were found to be less effective than cakes on this soil.

CROPS.

Sugar cane.—The question of ripening under different soil and climate conditions is under continuous study in Bengal, Behar and Assam.

Sanyal has carried out further experiments on windrowing at Pusa and shown that in certain cases here the condition of windrowed cane is better than corresponding uncut cane.

Oil seeds.—Norris has continued his enquiry on the cocoanut plant and fruit.

Somers Taylor has shown that high or low oil content is generally not an inherited character in castor seed. The oil content was found to depend upon cultivation and upon the degree of maturity of the seed.

Rice.—The rates of assimilation of nutrients and of development of the rice plant are being determined in Bombay.

Charlton in Burma has carried out an investigation on the parboiling of rice. The industry, though important, is a public nuisance owing to the objectionable fermentation which occurs.

Sterilisation by heat and bleaching powder, suppression of anærobic bacteria by blowing air, and frequent changes of water were the methods first tested. They had all to be abandoned for various reasons. Eventually good results were obtained by using acidulated water (P_h=5—P_h=2) which inhibited bacterial activity.

Opium.—Annett has continued the enquiry on the lines previously described.

In studying the factors influencing the morphine content of the latex he found striking differences in distribution of the alkaloids in the plant.

Codeine was found to be uniformly distributed whilst morphine and with it meconic acid were concentrated in the capsule.

Annett has further improved his process for the determination of morphine for estimating such small quantities as occur in a single capsule. This will greatly facilitate selection work.

Tea.—The officers of the Indian Tea Association have been engaged in studying the tannin content of the leaf and the changes taking place during withering. The tannin content was found to vary considerably not only in plants of different species but also in different plants of the same species.

It was found that the initial moisture content of the leaf was an important factor in controlling the changes taking place during withering. Leaf plucked in the morning in the turgid state developed more tannin during 18 hours of withering than drier leaf plucked later in the day.

Jute.—The composition of the jute plant at different stages of development has been studied by the Fibre Expert in connection with the incidence of fungoid disease.

Beans.—Charlton in Burma has examined a large number of cultures for HCN. content. 5 of these have been chosen for further separation into pure strains.

Cotton.—In Madras it has been found that the staple and colour of lint from a pure variety of cotton was appreciably different when grown on two distinct soil types. The work is being continued.

Indigo.—In Indigo Publication No. 6, by W. A. Davis, a second series of reports of manurial trials carried out by Bihar planters is discussed. On certain areas notably in the Champaran District, Super alone has given very marked increase of crops, both indigo and rabi crops such as oats. The majority of the soils in Bihar however are defective in humus as well as soluble phosphate and in these cases combined treatment with green manures (Sannai) and Super have given big increases of crops. Most of the soils in Bihar have a very high lime content (20 to 40 per cent $CaCO_3$) but a few exceptional soils are deficient in this constituent and need liming to improve texture.

The mode of action of phosphatic fertilisers in Bihar is discussed and emphasis laid in the great increase of root developement and nodule activity due to soluble phosphate.

Indigo Publication No. 8, by W. A. Davis, discusses the conditions affecting the quality of the Java indigo plant, especially indigo content of the leaf. Trials suggest that high quality is associated with a low nitrogen content in the soil, particularly with a low content of nitrate. When indigo is grown with a cover crop, such as wheat or mustard, the indigotin content of the leaf and the possible yield of indigo per acre may be increased 50 per cent or more.

Indigo Publication No. 9, by W. A. Davis, is a note on the possible development of indigo in Assam, where it grows with unusual luxuriance. Details are given of the difficulties encountered at Panchnoi Factory owing to the widely varying character of the water used for steeping from day to day as regards its contents of active indican-splitting bacteria.

Indigo Publication No. 9, by W. A. Davis, deals with the nature of the changes occurring during the extraction of indigo in the ordinary steeping

process. In this publication the very harmful effect of slight oversteeping —one or two hours—on both yield and purity of the indigo is emphasised. Such destructive action occurs when the bacterial fermentation in the vats produces much acidity, due to carbonic acid, the presence of which is very destructive of indoxyl. Different typical fermentations have been studied in detail and the results illustrated by graphs.

Indigo Publication No. 10 is a note by Major W. R. Atkins on the deterioration of indigo seed during storing and on the conditions necessary to avoid this.

APPLIED CHEMISTRY

Part II.—Forest Chemistry

BY

J. L. SIMONSEN,

Forest Chemist, Forest Research Institute, Dehra Dun

Essential Oils—(1) Turpentine.—Experiments on the chemistry of the sesquiterpene longifolene obtained from *Pinus longifolia* have been continued and some light has been thrown on the constitution of this interesting substance. It is hoped that when once the constitution of this substance has been elucidated some technical use may be found for it as at the present time it only finds a limited market as an inferior turpentine substitute. It has been suggested that it might be utilised for mineral flotation and experiments are being made in Burma to determine whether it can be used for this purpose.

(2) **Oil from the leaves of Skimmia laureola.**—The examination of the oil from the leaves of *Skimmia laureola* has been completed and the results have been published (Journal of the Society of the Chemical Industry, 1921, Vol. XI, 126T.).

(3) **Oil from Zanthoxylum seeds.**—The oil from the seeds of one species of Zanthoxylum, which has not been definitely identified botanically, have been examined and shown to contain d-linalol (50 per cent.) phellandrene, dipentene and methyl cinnamate. As this oil would appear to be of some value the oil from other species of *Zanthoxylum* obtainable in India are being examined.

(4) **Camphor.**—The experiments on the yield of camphor and camphor oil from leaves grown in Dehra Dun have been completed and the results published (Journal of the Society of Chemical Industry, 1920, Vol. XXXIX, 296T.). It is hoped to publish shortly a detailed analysis of the acreage yield of camphor with special reference to the question of establishing the camphor industry in India.

(5) **Boswellia serrata.**—Fowler and Malandkar have published details of their method for the separation of the turpentine, rosin and gum from the gum-oleoresin from *Boswellia serrata* (Journal Ind. Inst. Sc., Vol. IV, 27).

Fixed oils.—Preliminary experiments have been made at Dehra Dun on the oils from the seeds of *Garcinia Morella, Garcinia Cambogia, Mimusops Elengi.* The oil from olive seeds grown at Rawalpindi was examined and though the yield of oil was low it was of good quality.

Wood distillation.—Sudborough and Watson with collaborators have published Part III of their researches on wood distillation (Journ. Ind. Inst. Sc., Vol. III, 281). This part of the research is concerned mainly with the distillation of certain Mysore and Baroda woods under conditions similar to those used in the previous experiments. The results are given in a number of tables.

Medicinal products.—As the result of a careful analysis of a large number of samples of the leaves and flower buds of *Artemisia maritima* from Kashmir the presence of Santonin has been definitely established. This result has been confirmed in London by Greenish and Pearson (Pharm. Journ., 1921) and the question of the commercial extraction of this valuable drug in Kashmir is under consideration.

Miscellaneous.—Sudborough and Vridhachalam (Journ. Ind. Inst. Sc., Vol. III, 61) have investigated the extraction of tartaric acid from tamarinds. They show that the acid is readily recovered and are of opinion that tamarinds would prove an economic source of tartaric acid. This research confirms an unpublished research made with a similar object by Dr. B. B. Dey at the request of the Indian Munitions Board.

Fowler and Joshi (Journ. Ind. Inst. Sc., Vol. III, 39) have studied the fermentation of cellulose. They consider that it should be possible under certain conditions to generate power gas (methane) by the fermentation of waste cellulose materials which are frequently available in quantity as for example on the West Coast.

A valuable study of the biochemistry of the Mahua flower has been published by Fowler and his collaborators (Journ. Ind. Inst. Sc., Vol. III, 81). For details the original paper should be consulted as the results cannot readily be summarised.

ASTRONOMY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Solar Physics.—Researches in solar physics are carried on at Kodaikanal under the direction of Mr. J. Evershed. A description of the instruments was given in the report for 1918-19.

Routine Work.—Daily spectroheliographic records are obtained in calcium and in hydrogen light; the routine work also includes visual examination of sunspots and faculæ, sunspot spectra, and bright lines or displaced lines in spots and in prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review" while for more technical purposes bulletins and memoirs of the observatory are issued. Of the former 66 have appeared and of the latter 2 have been published.

Spectroscopic Research.—The study of the variations in the Sun-arc displacements was continued up to the end of 1920, the spectrograph being adjusted for the spectral region 4300-4500 and remaining unaltered throughout. Local displacements on the Sun's disc were avoided by using general sunlight instead of taking the light from the centre of the disc. A small progressive increase in wave-length is shown in some of the lines, and the mean shifts of these lines for the year 1920 show an increase of about 0·002A as compared with similar values obtained in 1919. The changes of wave-length observed are far in excess of the probable errors of measurement.

A series of spectra of Sun and arc have been obtained and partly measured of the ultra violet region, including the high level calcium lines H and K, two aluminium lines, and numerous iron lines as well as the cyanogen bands. These spectra are taken at the polar and equatorial limbs of the Sun and at the centre of the disc. Other series taken at the same positions on the Sun include the iron lines at the red end of the spectrum and the D lines of sodium. The object in view is to redetermine as accurately as possible the displacements in the Sun of lines representing high levels and low levels, and to find the relation between displacements and wave-length at both limb and centre of disc.

The results of our measures of iron lines in Sun and arc will be used also to determine the absolute wave-lengths of selected lines in the solar spectrum based on the International system of iron arc standards. These will be communicated to the International Committee on Standards of wave-length.

Spectra of Venus have been obtained in December 1920 and in June 1921 with the planet near eastern and near western elongation respectively, and photographs will be continued until the angle Venus-Sun-Earth becomes as

large as possible. The spectra obtained near the elongations yield negative evidence as to the planet's rotation which appears to be much slower than that of the Earth. The shift of the lines in these spectra is practically the same as in the spectrum of direct sunlight, the angle Venus-Sun-Earth being small.

A new auto-collimating prism spectrograph of long focus and high resolving power has been partly constructed in the observatory workshop. It is intended to supplement the grating spectrograph for weak light sources and especially for Venus spectra when the available time of exposure becomes too short for satisfactory grating photographs, owing to the approach of the planet to superior conjunction with the Sun.

Prominence Frequencies.—In the study of the solar prominences a remarkable relation has been found between the eastern excess of prominences in the northern and southern hemispheres considered separately and the heliographic latitude of the Earth. It appears that during the series of years between 1904 and 1917 when there was a constant excess of eastern prominences this excess was always greater in the hemisphere inclined away from Earth than in the hemisphere inclined towards Earth. The mean results indicate that the eastern excess varied in accordance with the sine curve showing the variations in the inclination of the sun's axis to the line of sight.

METEOROLOGY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Upper Air.—Work with pilot balloons was continued at several stations under the direction of the Agra Upper Air Observatory. The shortage of funds which resulted from a general revision of pay necessitated the closing of the balloon stations at Akyab, Calcutta and Bombay and caused the loss of several trained members of the staff. Nevertheless it was possible to make some headway in the discussion of the upper air data of cloud wind and temperature gathered during the war years.

Normal values of upper winds at nine stations in India were published for the use of aviators, while a discussion of the cloud observations made between 1877 and 1914 was also printed; these two papers form parts IV and V of Vol. XXII of the Memoirs.

Daily and seasonal forecasting.—Shortness of staff prevented any of the gazetted officers from carrying on the preparation of type maps for daily forecasting; but the presence in the Simla office of Mr. J. C. Kamesvara Rao, who was deputed by the Calcutta University to work at meteorology, enabled progress to be made. Mr. Rao has made a careful analysis of all the cold weather storms of the past 20 years.

The methods of forecasting for the cold weather rains as well as for the monsoon have been advanced a stage further. The best result is that for the monsoon rainfall of the Peninsula for which a formula based on 45 years' data of only three factors yields a correlation coefficient of ·73.

Theoretical Meteorology.—An investigation was made into the application of wet bulb temperatures in thermodynamical problems, and some important conclusions about the relationship between adiabatic processes and wet bulb temperatures were arrived at.

A short discussion on dust-raising winds was prepared for publication.

TERRESTRIAL MAGNETISM

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., F.R.S.,
Director-General of Observatories.

Magnetic observatories—Bombay (Alibag).—For a description of the instruments and of the routine work reference should be made to the Annual Report of the Director, Mr. T. K. Chinmayanandam.

Magnetic Survey.—No. 18 Party (Magnetic).—The declination, horizontal force and vertical force magnetographs continued in operation throughout the year at the Dehra Dun and Toungoo observatories, and daily absolute magnetic observations were taken regularly by the observers in charge. The observatories were visited during the field season and observations, consisting of declination, horizontal force and dip, were taken for the comparison of instruments.

The Kodaikanal and Alibag Observatories, under the control of the Meteorological Department, were also visited by the officer in charge of the magnetic survey for the same purpose.

Observations at repeat stations.—Six repeat stations at even distances apart, most of them *en route* to the observatories, were selected and observed at this field season. These stations will be visited annually to take magnetic observations with the object of ascertaining in what year, during the interval of the 5-yearly observations at all repeat stations, a turn in the curve of secular change is indicated, so that it may be possible to determine with greater accuracy the rate of annual change which the magnetic elements undergo in different parts of India.

Reduction of observations to epoch.—The reduction of the observations at the field and repeat stations in India, which was last year reported to be under revision, is now well in hand and will be completed about the end of this year.

The magnetic elements at observatories.—The computation and tabulation of the provisional values of dip, declination, horizontal force and vertical force for the three observatories Dehra Dun, Toungoo and Kodaikanal, for the year 1920, have been completed; the mean values of these elements

derived from all days, excluding those of great disturbance, are given in the table below :—

Mean values of the magnetic elements at observatories in 1920.

Observatory.	Latitude and Longitude.	Dip.	Declination.	H. F.	V. F.
				C. G. S.	C. G. S.
Dehra Dun	30° 19′ 19″ N 78 3 19 E	N. 44° 59 9′	E. 1° 52· 0′	·32951	·32949
Toungoo	18 55 45 N 96 27 3 E	N. 23 7·7	W. 0 23·7	·39114	·16707
Kodaikanal	10 13 50 N 77 27 46 E	N. 4 3·61	W. 1 49·9	·37787	·03042

Great magnetic storm.—A magnetic storm of great intensity, which seriously interrupted the working of the telegraphs in India, was recorded at the observatories from the 13th to the 17th May 1921. The magnitude of the storm was greater and its duration three times longer than the big storms of the 11th and 12th August 1919 and 22nd March 1920. The storm began suddenly and simultaneously in all the magnetic elements at 13h. 8m. G. M. T., on the 13th May; it was practically simultaneous at all the magnetic observatories, to the degree of accuracy with which it is possible to measure time on the magnetograms. There is much similarity in the main features of the disturbance at all the observatories. The horizontal intensity was principally affected, and a prominent feature in this element was the great speed and amplitude of the disturbance between 21h. 20m. and 21h. 41m. G. M. T. Minor rapid fluctuations followed, and the greatest activity in all the magnetic elements began on the 14th at 22h. 15m. G. M. T.; this lasted for about 10 hours, during which time the movements in the horizontal intensity were so rapid that no record was obtained on the trace in the downward movement, which was the greatest phase of the storm. After this there was a gradual rise in the horizontal intensity up to about 2h. 20m. G. M. T., on the 16th with frequent long and short period oscillations, and between 9h. and 10h., G. M. T., a depression again occurred when the trace once more went beyond the limits of the magnetogram. A gradual rise with minor oscillations then continued up to 7h. 48m. G. M. T., on the 17th when the storm ceased.

It is noteworthy that as usual this storm synchronized with a reported display of Aurorae and with the appearance of large sun-spots.

GEOLOGY

BY

E. H. PASCOE, M.A., D.Sc., F.G.S.,

Director, Geological Survey of India.

Stratigraphy.—The examination of the Tertiary outlier north of Simla was continued. The Shali Limestone was found to be dipping unconformably beneath a bed of white sandstone which has been called the Shali Sandstone and this in its turn was seen to be overlain by the series of slaty shales in which Sir Henry Hayden discovered nummulite bands and which have been called the Madhan Slates. Similar fossils have been found in two other localities in this series. A shelly limestone occurs also in the Madhan Slates, and for some distance forms the boundary between these Slates and a series of older overlying limestones and slates, of which the limestone bears a resemblance to the Krol Limestone. The nummulites in the Madhan Slates, so far as they are determinable, appear to be of Subathu age. The Shali Limestone is therefore either Eocene in age—perhaps the Lower Nummulitic of the Punjab—or Cretaceous. It seems probable that the older limestone and slate overlying the Madhan series has been thrust over the latter, or that an over-fold has inverted the sequence of the beds, the Madhan series having originally been a Tertiary outlier lying upon the older limestone and slate.

During an investigation of the Mandi salt deposits, the presence of bitumen in the associated marls was confirmed. The salt is a stratified deposit, and this recent work tends to confirm the view that it and its associated marls belong to the Subathu stage of the Nummulitic series.

Geological Surveys.—The survey of the ferriferous belt of the Feudatory States of Bihar and Orissa was continued, as was also the general systematic survey of the Central Provinces. Considerable progress was also made with the systematic survey of Mergui. A report on the geology of the Takki Zam valley and the Kaniguram-Makin area in Waziristan will shortly be published. The rocks encountered ranged from a series containing dark blue and black shales and occasional thin black and dark blue limestones, both types being characterised by plant impressions, up to Recent Alluvium. The plant series may prove to be Jurassic. Cretaceous, Nummulitic and Siwalik rocks are all represented, the Murree series not being recognised.

Economic Enquiries.—Investigations were made regarding the following minerals: coal in the Bedadanol coalfield, Godaveri district, Madras; iron in Keonjhar and Bonai States; kaolin in the Thaton district of Upper Burma

and also in the Belgaum district of Bombay ; salt at Guma and Drang in the Mandi State, and tin in the Mergui district, Burma.

Several sites for dams were examined and reported on during the year and the question of water-supply was gone into with regard to Matheran near Bombay, Amraoti in Berar, and Taungzin and Kyaukpadaung in the Myingyan district of Upper Burma. The superintendence of the boring for coal below the Deccan Trap at Bhusawal was continued, and a geological reconnaissance of the alignment of the proposed railway up the Ganges valley from Hardwar to Karanpryag was made.

GEODESY

BY

LIEUTENANT-COLONEL H. McC. COWIE, R.E.,

Officiating Superintendent of the Trigonometrical Survey.

The only systematic field work undertaken during the year by the Trigonometrical Survey consisted of Precise Levelling, Magnetic Observations and Tidal Registration. Experiments were made in connection with wireless Longitude determinations and investigations into atmospheric refraction and the adjustment of triangulation nets were continued. No Triangulation was undertaken nor were any Pendulum or Astronomical Observations made.

TIDAL OPERATIONS.

During the past year tidal registration by means of automatic gauges have been carried out at the following ports :—

Aden, Karāchi, Bombay (Appolo Bandar), Bombay (Prince's Dock), Madras, Kidderpore, Rangoon, Moulmein and Port Blair.

All the tide gauges have worked satisfactorily, and there have been no serious breaks in the tidal registration.

All the tidal observatories were inspected during the year and the gauges thoroughly overhauled and put into working order.

In addition to the automatic tidal registration at the nine ports named above, observations of high and low water on tide poles were taken during day light at Bhaunagar, Chittagong and Akyab, with the object of testing the accuracy of predictions which were based on tidal registrations taken many years ago.

The Director, Inland Water Transport, Basrah, has continued to supply to this Department tidal observations taken on a tide pole at Basrah. On the basis of these observations, data for the preparations of tide tables for Basrah for the year 1921 were prepared and supplied to the National Physical Laboratory in England. The predictions were received from the Laboratory in December 1920 and supplied direct to the Director, Inland Water Transport, and Port Officer, Basrah, and the Director of the Royal Indian Marine, Bombay, in December 1920.

Data for the preparation of tide tables for Basrah for 1922 were despatched to the Director, National Physical Laboratory, in January 1921.

Arrangements have been made to transfer the Tide Predicting Machine from the National Physical Laboratory at Teddington to Dehra Dun. This instrument was originally installed in the India Office Stores Department about the year 1879, and subsequently moved to the National Physical Laboratory. It is expected that the machine will be in working order in Dehra Dūn about the end of October 1921, after which date the preparation of Tide Tables will be undertaken in India.

LEVELLING OPERATIONS.

I. *Levelling completed in 1920-21—*

During the season 1920-21, the following lines of precise levels were run :—

A.—*Jacobābād to Hyderābād*, about 350 miles. This line traverses the area commanded by the Sukkur Barrage project and the Manchar Lake Irrigation Scheme, and forms data for irrigation work on the right bank of the Indus. In the course of time many of the old bench-marks had disappeared in this area. The determination of the heights of a considerable number of the Public Works Department bench-marks was completed. The work was of the "high precision" order, executed on the "fore and back" system, and forms one of the lines of the new level net.

B.—*In the United Provinces—*

(*a*) Bareilly to Pīlībhīt (Revision); originally levelled in 1867-68.

(*b*) Pīlībhīt, *viâ* Mailānī, Kherī Lakhīmpur, Sitāpur, Baghauli, Lucknow, Rāe Bārrīely, and Sultānpur to Fyzābād.

(*c*) Mailāni to Shāhjahānpur.

(*d*) Shāhjahānpur to Baghauli.

(*e*) Sultānpur to Allahābād.

This work was undertaken at the request of the Irrigation Department, in connection with the Sarda Canal Project, in order to furnish bench-marks accurately determined and referred to a common origin, which would provide a base to enable the Irrigation Engineers to co-ordinate all their cross-levels throughout the entire lengths of the main canals and their distributaries.

The total distance levelled including branch lines was 596 miles executed on the old system of simultaneous double levelling.

C.—*In Bengal* (including branch lines about 460 miles).

(1) Chākdaha *viâ* Berhampore to Chuādānga, with branch-line from Berhampore to Lālgolā (New).

(2) Poradāha *viâ* Nator, Rājshāhi, Godāgāri and Mālda to Hyatpoor, crossing the Padenā by direct levelling over the Sāra bridge, the observed difference (old-new) of height between the two embedded bench-marks on either bank being 0·112 foot. It was originally crossed by (*a*) Vertical Angles, (*b*) Levelling and (*c*) Tide pole methods.

(3) Jiāganj to Bengal-Bihar boundary near Farakka police station, 59 miles.

This levelling in Bengal was taken up for the Nadiā Rivers Scheme, and was carried out on the simultaneous double levelling method.

D.—*In Bihar and Orissa.* (Including branch lines about 230 miles.)

(1) Hyatpoor *viâ* Manihāri to Rautara for the Nadiā Rivers Scheme (New),

(2) Tinpāhār to Bihar-Bengal boundary near Farakka police station, 26 miles (New, for Nadiā Rivers Scheme).

(3) Darbhangā to Bagahā for the Irrigation Department (New).

The method adopted was simultaneous double levelling.

E.—*Muttra to Mārwār Pāli*, in the United Provinces and Rajputana. (Total distance about 360 miles.)

This line was levelled on the " fore and back " system and forms line 107 of the new level net.

F.—*Lahore City Levelling.*

The heights of 259 bench-marks in Lahore were fixed at the request of the Punjab Government in connection with the City Sanitation Scheme. In addition to these, the heights of about 100 traverse stations were fixed in connection with the large scale survey of the city now in progress.

II.—*Levelling for earthquakes.*—

In connection with the results of the levelling in the Srimangal Earthquake area, noted in the last report to the Board of Scientific Advice, it has been decided to send each year a copy of the levelling programme for the ensuing season to the Director of the Geological Survey, and to ask him whether there are any geological faults in the neighbourhood of the lines. Stable check level bench-marks will then be constructed and levelled to during the work, to enable relevelment to be undertaken after any future earthquake in that area.

GEODETIC RESEARCH AT DEHRA DUN

BY

J. DE GRAAFF HUNTER, M.A., Sc.D., F.INST.P.

(1) Wireless Longitude Observation.—January—March 1921. A Marconi Multi-valve amplifier and detector, type 55 A, was lent by D. D. A. S. : and Lieutenant C. E. Sketch, 3rd Wireless squadron with 4 B. O. R.'s brought this to Dehra and explained its use. Paris signals were picked up on the third day, and, after that, on most mornings of observations. Nauen (Berlin), Caernarvon and Tokyo were frequently heard. At the outset atmospherics were troublesome. Two aerials were tried, one 72 feet high, in the Survey office compound among trees, and the other 100 feet high on the maidan, in the open. The latter gave somewhat louder signals, but atmospherics were not reduced, as had been hoped. A still greater disturbance was caused by the working of some Central Asian station, on the same wave-length as Paris. Quetta interfered several times, until the Director of Wireless issued orders that there should be no signalling of messages at the time of the time signals.

The Paris signals are of two kinds (1) ordinary, in which the precise times 11-45, 11-47, 11-49 (night) are indicated by the beginning of a bar, after suitable warning signals, and (2) scientific, in which 300 dots equally spaced are sent out in about 293 seconds, beginning shortly after 11-00 (night, Greenwich time). The precise times, to 0·01 second, of first and last dots, are signalled after the ordinary time signals are finished. These dots are heard in a double telephone receiver, in which the clock beats are also made audible. The dots gradually overtake the clock beats, and it is only necessary to note the moment at which the two coincide, as they do 5 times in a set.

Coincidences were successfully noted on 5 mornings by Dr. Hunter, and on two mornings by Major Mason. Time stars were taken before and after the wireless signals. The results obtained cannot at present be cleared of personal equation in time determination, as the Dehra transit is not fitted with an "impersonal micrometer."

The following are the values of the difference of Longitude from Greenwich that have been determined :—

5 hours 12 minutes 11·220 seconds, by Dr. Hunter
5 „ 12 „ 11·383 „ , by Major Mason. } by wireless 1921.
5 „ 12 „ 11·267 „ , by Sir Sidney Burrard, and Sir Gerald Lenox-Conyngham in 1894-96 by ordinary telegraph by land and sea.

The experiments have shown the feasibility of the method for determining the longitude of any Indian station, by direct reference to the Greenwich meridian. It is also clear that it is necessary to fit an "impersonal micrometer" to transit instruments used for this work.

(2) Investigation of atmospheric refraction.—It was noticed in 1913 (*vide* Professional Paper 14 Survey of India, chapter iv) that the diurnal change in refraction was in some cases very closely a linear function of the temperature. In two cases examined the greater diurnal change occurred on the shorter ray. This was considered surprising and no explanation was forthcoming. In relation with this question simultaneous observations of barometers at Mussoorie and Dehra were made at several hours of the day for 23 days. The difference of height of the two barometers was deduced by formula from these readings and was found to differ from the spirit levelled difference of height by amounts which varied at the different hours as follows :—

Hour.	8	10	12	14	16
Barometric height *minus* Spirit Level height in feet.	—65	—19	+7	—4	—17

In endeavouring (1921) to explain the diurnal change in refraction, an attempt was made to work out the relation between temperature variation of the air at various heights with that at ground level. It appears that the variation may be split up into two parts (1) conduction effect, (2) radiation effect. The first effect diminishes rapidly with height, and at 100 metres will not exceed 1 per cent. of its value near the ground. The second effect, probably depending a good deal on the state of humidity, should be much the same at all heights dealt with.

As regards the refraction, the second effect has but little influence ; for the main determining factor is the gradient of temperature with height. The conduction effect is very much greater. Its effect is easily computed for a ray of light which soon passes out of the conduction region. If α is the angle of elevation of the ray and $\delta\tau_c$ is the portion of the variation of temperature from its maximum value, which is due to conduction, the change in refraction resulting is given by applying $\mu \sin \phi = \mu' \sin \phi'$ at the ground level and at a height of (say) 100 metres. Then $\delta\mu \propto \delta\rho \propto \delta\tau$ and the refraction $= A\delta\tau_c \cot \alpha$ where A is a physical constant. It is found in cases dealt with that if $\delta\tau_c$ is taken equal to $\frac{5}{6}\,\delta\tau$, where $\delta\tau$ is the defect of temperature near surface from maximum, that the observed changes in refraction are closely explained.

It appears that the radiation portion $\delta\tau_r$ of the temperature variation is of the form $a\,\delta\tau + b\,\frac{d\tau}{dt}$, t being the time. In the barometric formulæ it is necessary to get the mean value of $\frac{1}{\tau} = \left(\frac{1}{\tau}\right)_m$; usual formulæ have put this

equal to $\frac{2}{\tau_1 + \tau_2}$ where τ_1, τ_2 are the temperatures observed at both ends. This value of $\left(\frac{1}{\tau}\right)_m$ is not likely to be correct when there is a much larger variation of temperature near the surface than in the higher layers of air. In fact it is clear that much better results will be obtained if $\delta\tau_c$ is applied to the observed temperatures. The barometer results uphold this view and the observations at 8, 10, 12 hours fall nearly on a straight line when plotted against temperature observed near the ground. Observations at 14 and 16 hours fall distinctly to one side of this line. The explanation seems to be in the term $\frac{d\tau}{dt}$; in fact an empirical expression $a' \delta\tau + b' \frac{d\tau}{dt}$ can be found which closely represents the tabular quantities given above. This also leads to the partition of temperature variation into two parts about in proportion of 5 : 1 due to conduction and radiation respectively. What has been said about conduction effect is primarily applicable to a station in a plain. At a hill top convection will cause a readjustment. On this account the diurnal variation in refraction from a hill station is less than it would be at a plateau station. Observation has shown this to be the case.

According to this reasoning the following seems to be probable—

(1) The line representing temperature of air plotted against height is practically straight at about 14 hours, right to within a few feet from ground.

(2) At earlier hours in the day the general slope of this line is not much changed; but it is displaced as a whole to a smaller temperature and its termination near (say within 100 metres of) the ground is now curved towards the direction of lower temperature, the curvature increasing as the earth is approached.

It now appears possible to represent the refraction on a ray which does not lie close to the ground, at any time in the form, $kc + f A (\tau_m - \tau) \cot \alpha$ in which c is the length of the ray in seconds of arc, k is a factor depending on temperature and pressure of the air at the observing station, α is the angle of elevation of the ray, τ is the temperature and τ_m its maximum value, A is a constant and f is a factor so far found to be about $\frac{5}{6}$.

The observations to determine the height of Mount Everest have been partially dealt with, using this formula and this has resulted in improved accordance in the height obtained by each observation.

(3) Adjustment of triangulation networks.—The simultaneous adjustment of a network of triangulation to surrounding triangulation according to the general method of least squares involves the solution of such a great number of simultaneous linear equations as to be quite impracticable. To solve say 20 simultaneous equations is a work which will occupy a computer the best part of a week; and when it is remembered that the labour increases

as the cube of the number of equations it will be seen that to solve say 100 simultaneous equations will occupy some two years making no allowance for mistakes. Now in a network the errors to all the angles enter the equations simultaneously, so that quite a small network would give rise to an enormous amount of labour. By a little generalisation the problem may be solved in a way which leads to results wholly consistent *inter se* and departs but little from the adjustment which is most probable.

First consider the case of a network of equilateral triangles all of the same size, with angles all equally carefully measured and so all having the same probable error. Consider next that the size of these triangles is small compared with the area dealt with. Both of these modifications lead to a case not seriously different from the actual case — for it is always the object of the triangulator to select triangles nearly equilateral. We are led then to the case of a uniform plate which has to be strained to fulfil certain given conditions of closure.

If we take ξ and η to be the movement of any point parallel to axes Ox, Oy and introduce the condition that at any point the scale value and azimuth is changed by the same amount for all azimuths, the following equation must hold $\frac{\delta^2 V}{\delta x^2} + \frac{\delta^2 V}{\delta y^2} = o$ ..... (1) where V is put equal to ξ or η.

Also $\frac{\delta \xi}{\delta x} = \frac{\delta \eta}{\delta y}$ and $\frac{\delta \xi}{\delta y} = -\frac{\delta \eta}{\delta x}$ (2) It also follows that the change is in azimuth δA and in scale value ϵ (*i.e.*, new scale : old scale : $1 + \epsilon : 1$) that δA and ϵ are of form $\frac{\delta \xi}{\delta x}$ and $\frac{\delta \eta}{\delta y}$. These values are applicable to a point. To find the effect on a line they have to be integrated along that line, which is easily done. The problem is accordingly reduced to the solution of (1) subject to the given closing conditions.

The solution of (1) is of form $\Sigma A_n r^n \cos(n\theta + \delta_n)$. By taking enough terms it is possible to satisfy any number of conditions : whereby suitable values of A_n and δ_n are obtained. It is to be noted here that the number of simultaneous linear equations for solution is equal to the number of conditions to be satisfied.

A variety of solutions can be found : but it is clear that the most probable one is that which involves the smallest values of n and this solution is the actual most probable solution of the hypothetical case.

The solution is simple when there are only a few conditions to be satisfied— say the closure on a single side, which involves the solution of only four simultaneous equations.

After the equations have been solved it is necessary to compute values of ξ, η, at sufficient numbers of points to draw contours of equal value ; and this is the heaviest part of the work if large values of n occur. If this is done on tracing cloth, it can be superposed on the chart of triangulation and the correction at any point may be immediately read off.

To visualise the process we introduce the idea of change of azimuth and scale *at a point*, and so imagine in actual triangulation that the rays joining the points become slightly curved. If we imagine a plate of uniform strength with the triangulation marked out on it, then by straining the plate (within its elastic limits, and without buckling it) to fit the closures, all the triangulation on it would be deformed in the way described. It is clear from this that the actual case would be represented by the distortion of the plate of strength varying from point to point which enables us to estimate how far the solution departs from that actually most probable. The method has been devised primarily to deal with adjustment of minor triangulation.

BOTANY

I.—BOTANICAL SURVEY

BY

A. T. GAGE, LIEUT.-COL., I.M.S.

Director, Botanical Survey of India.

Systematic.—Eastern India and Burma.—In the forests of the northern third of Tavoy District in Southern Burma, Mr. P. T. Russell, Superintendent of Cinchona Cultivation there, has made excellent collections. The Director visited the same area early in 1921 and also brought back a collection. The district is botanically rich and these preliminary collections have already yielded rare and interesting species. The distribution of Floras in S. E. Asia as affected by the Burma-Yunnan range of mountains, has been studied by Captain Kingdon Ward. In the Kew Bulletin has been published a paper by the late Major S. M. Toppin, M.C., on the Balsams of the Kachin Hills. In the same journal descriptions of the new species in the collections made by Mr. I. H. Burkill some years ago in the Abor Hills continue to appear. In Notes from the Royal Botanic Garden, Edinburgh, Sir Isaac Balfour and W. W. Smith have published new species of *Primula*, *Omphalogramme*, *Rhododendron* and other genera from the Eastern Himalaya and Upper Burma.

Northern India.—Part II of Vol. III of the Flora of The Upper Gangetic Plain, by J. F. Duthie appeared in 1920. It contains the families from *Coniferae* to *Juncaceae*. This work is now nearly finished, and it is hoped that by another year publication will be completed. Mr. R. N. Parker of the Imperial Forest Service has discovered several hitherto-undescribed species in the North Western Himalaya. Professor S. R. Kashyap has published an interesting note on the vegetation forming the floating islands of Riwalsan, a lake in Mandi State. The Balsams of Chitral are referred to in Major Toppin's paper mentioned above.

Western India.—The Rev. Father Blatter and Professor Hallberg continue to show great activity on this side of India, their contributions to botanical literature during the year including a paper on new species of various genera found in the Bombay Presidency, studies of the Flora of Jodhpur and Jaisalmer, and of the Flora of Baluchistan. The drought resisting plants of the Deccan form the subject of a paper by Mr. R. K. Bhide.

Southern India.—During September and October Mr. V. Narayanswami of the Botanical Survey explored the Rampa country of the Godavari District. His collections, ranging from 500 to 4,500 feet of altitude are being worked out as opportunity allows, and promise interesting results. Collections were also made in Alamanda, Polakol, the Pulney and Nilgiri hills and in Kasargode and Tinnevelly by Mr. K. Rangachariar Avergal, the Madras Government Systematic Botanist and his assistants. The same botanist has under preparation separate lists of plants for the various districts of the Madras Presidency to facilitate compilation of district Floras hereafter. Mr. J. S. Gamble, C.I.E., has published in connection with the preparation of his Flora of Madras a fresh lot of new species from Southern India. The *Volvocaceæ* of Madras form the subject of a paper by Mr. Ayyangar.

General.—A large number of papers not concerned with purely regional botany have appeared during the year, of which only a selection can be mentioned here. Mr. H. H. Haines, C.I.E., has cleared up a nomenclatural confusion hitherto obscuring the use of the names *Amoora spectabilis* and *A. Wallichii* and *Sapindus trifoliata* and *S. laurifolia*. Dr. H. H. Mann has published an account of variation in the flowers of *Jasminum malabaricum*, and Mr. S. H. Prayag observations on the inflorescence and flowers of the grape. The physiological anatomy of the plants of the Indian desert has been studied by Mr. T. S. Sabnis and the structure of some Cucurbitaceous tendrils by Mr. K. D. Sawhney. The œcological aspects of the vegetation of the Upper Gangetic Plain have been investigated by Dr. W. Dudgeon. A case of atrophic abortion of the inflorescence of the Onion has been recorded by Mr. P. M. Debbarman.

II. Economic.—During the year Cinchona work in Tavoy has been continued under the difficult circumstances inseparable from all pioneer work in trackless tropical forests. So far as nursery work is concerned the results have been excellent, seedlings germinating and growing very well. The real test, however, as to how the young plants when planted out in the open, will stand the heavy monsoon precipitation that occurs in the south-western corner of the reserved area, where operations have been started, has yet to be passed. If the young plants planted in the open at the beginning of the monsoon do not come through it satisfactorily, it does not necessarily follow that the whole reserved area is to be incontinently condemned as unsuitable. It may be found that altering the period of planting out from the beginning of the monsoon to near its end will enable the young plants to be sufficiently established to withstand the full fury of the following monsoon. On the other hand it may be found necessary to move further inland, or to the southern third of Tavoy District or the northern third of Mergui District, where the rainfall is considerably less than in North Tavoy. Another year's experience will be necessary, before sufficient data can be gathered on which to base a definite opinion as to the future action to be taken.

BOTANY

II.—ECONOMIC BOTANY

Part I.—Agricultural Botany

BY

ALBERT HOWARD, C.I.E., M.A., A.R.C.S., F.L.S.,

Imperial Economic Botanist.

The present report, which is limited to four pages of print, deals with the progress of Agricultural Botany in India during the year ending June 30th, 1921. Under these conditions, the best course would appear to be to limit this paper to an account of the more important results published during the year and to refer the student of Indian agriculture for further details to the various other annual reports and periodicals issued by Government which deal with the same subject but in greater detail.

The following publications contain a considerable amount of information on the improvement of crops :—

(*a*) *Review of Agricultural Operations in India.*—This is an annual report, prepared by the Agricultural Adviser to the Government of India, Pusa, Bihar, and deals, among other matters, with the distribution of improved seed in various parts of India. It also contains a classified list of papers on Indian agriculture published during the year.

(*b*) *Scientific Reports of the Agricultural Research Institute*, Pusa (including the Reports of the Imperial Cotton Specialist and of the Sugar Bureau). Copies can be obtained from the Director, Agricultural Research Institute, Pusa, Bihar.

(*c*) *Administration Reports of the Provincial Departments of Agriculture.*—Bombay, Bengal, Madras, Central Provinces, United Provinces, Punjab, Bihar and Orissa, Assam and Burma. These are issued by the Government presses in these Provinces towards the end of each year and contain a general summary of the work of the Agricultural Department (including the farm reports) and also the annual reports of the Economic Botanists. These administration reports largely form the basis of the annual *Review of Agricultural Operations in India.*

(*d*) *Proceedings of the Board of Agriculture in India.*—This contains the programmes of work in progress in Economic Botany as well as discussions on matters relating to the Agricultural Department as a whole. Copies can be obtained from the Agricultural Adviser to the Government of India, Pusa, Bihar.

(*e*) Many of the original papers on Agricultural Botany in India are published in the following periodicals :—(1) *Memoirs of the Department of Agriculture in India* (*Botanical Series*), (2) *Bulletins of the Agricultural Research Institute, Pusa* and (3) The *Agricultural Journal of India*. This latter contains classified lists of all papers published on Indian agriculture. Copies of these publications can be obtained from the Director, Agricultural Research Institute, Pusa.

The number of original papers which appeared during the year under review is smaller than usual due to the absence on leave of several of the investigators, to the promotion of others and to vacancies among the superior staff. A number of important papers, however, have recently been submitted for publication and are now in the press. These will be dealt with in the next report.

Cotton. An account of Kumpta cotton (*G. herbaceum* L.) has been published by G. L. Kottur (*Mem. of the Dept. of Agr. in India, Botanical Series*, X, 221). The paper contains full details of the distribution of this cotton in the Dharwar tract and of a number of promising selections which have been isolated. Further work on the improvement of these types by hybridization is in progress. Several papers dealing with the cotton flower have recently appeared. G. L. Kottur (*Agr. Jour. of India*, XVI, 52 and 406) working in the Southern Division of the Bombay Presidency with types of *G. herbaceum*, *G. neglectum* and Dharwar American cotton considers that continuous self-fertilization for a number of years does not encourage self-sterility. Further work on this question is desirable as other workers state that continuous selfing may be injurious. The matter can only be cleared up by critical work extending over a number of years on unit species of a number of the different varieties. K. I. Thadani in Sind (*Agr. Jour. of India*, XV, 393) finds from a study of single plant cultures that from 5 to 8 per cent. of natural crossing takes place. In several cases, cleistogamic flowers were noticed on plants going off their bloom. G. R. Hilson (*Agr. Jour. of India*, XVI, 235) gives an account of the deterioration of Cambodia cotton in Madras and the methods of improvement in progress.

Rice.—G. N. Rangaswami (*Agr. Jour. of India*, XVI, 156) has published an interesting account of the methods in use at Coimbatore in the breeding of swamp rice. K. V. Joshi (*Poona Agr. College Mag.*, XII, 4 and 106) has commenced a series of papers on this crop. In transplanting, the old roots die, new ones being produced from 24 to 48 hours afterwards. In a week, the plants begin to recover from the process and with the rapid formation of the

secondary root system the crop loses its faded yellow colour and turns green. S. C. Roy (*Agr. Jour. of India*, XVI, 365) has published a preliminary classification of the wild rices of the Central Provinces which are important weeds in the rice areas of this tract mixing readily with the cultivated forms on account of the premature falling of the grain.

Sugarcane.—C. A. Barber, in the issue of the *International Sugar Journal* for October 1920, concluded a series of ten papers on the growth of the sugarcane. T. S. Venkatraman and R. Thomas (*Agr. Jour. of India*, XVI, 24) gives their experience of the methods tried at Coimbatore in dealing with imported sugarcane varieties during the first years of their trial under new conditions. N. V. Rao (*Agr. Jour. of India*, XV, 418) deals with the importance of habit in sugarcane varieties.

Indigo.—W. R. G. Atkins (*Pusa Indigo Publications*, 10) has investigated the deterioration of indigo seed during storage. The results indicate the importance of the seed being well matured before gathering. Those seeds with specially resistant cuticle retain their germinative vigour to the greatest extent.

Opium.—H. E. Annett and his assistants (*Bull. 116, Agr. Research Inst., Pusa*) find that the type of improved opium poppy recently isolated at Cawnpore does not produce opium of the same morphine content in every district. There appears to be some local factor still to be investigated which influences the power of the plant to form morphine. Certain Districts, such as Etawah, Cawnpore, Budaun and Bareilly, produce opium of high morphine content while others such as Fyzabad, Gorakhpur and Rai Bareli yield a drug much lower in morphine.

Fibres.—Two papers on fibres have appeared during the year. B. C. Burt (*Agr. Jour. of India*, XV, 616) gives the results of preliminary experiments with flax at Cawnpore and discusses the possibilities of establishing a flax industry under canal irrigation on the alluvium. R. S. Finlow (*Agr. Jour. of India*, XVI, 265) has published an historical account of his experiments on jute in Bengal including the problem of the seed supply of improved types to the cultivators.

Fruit.—W. Burns and S. H. Pryag have published a detailed account of the mango in Bombay in Bulletin 103 of the Bombay Department of Agriculture. Although the paper is intended for growers, there is a useful chapter on the flowering and pollination of this tree and a classification of mango varieties. Several other papers on fruit have appeared in the *Agricultural Journal of India*. W. Burns and P. G. Joshi deal with the "top-working" of the mango. S. H. Pryag has written a general paper on the influence of the stock on the scion and has made some observations on the inflorescence and the flowers of the grape. The root systems of the guava and of the orange have been studied by Burns and Kulkarni under the soil conditions obtaining in the Deccan.

Millets.—L. C. Coleman and his staff have published an exhaustive account of the cultivation of *ragi* (*Eleusine coracana*) in Mysore and of the results obtained on this crop at Bangalore. Cross-fertilization is stated to be practically impossible under Mysore conditions, a fact which has greatly simplified the testing of varieties and the distribution of seed.

Forage plants.—The important question of the improvement of the poor grazing areas of the Deccan has been taken up by W. Burns and G. M. Chakradev (*Jour. of Indian Botany*, II, 84). An area of denuded grazing land has been leased for five years near Poona. This has been fenced and careful observations on the changes in the flora are being made. The results so far obtained are of considerable interest. Even in the higher and rocky parts of the area, the good perennial fodder grasses *Iseilema laxum* and *Andropogon monticola* have firmly established themselves. It is considered probable that the climax will be an *Acacia arabica* forest and that the ideal condition would be grass land containing the better fodder grasses with a scattered growth of this tree sufficient to shade not more than a tenth of the land. L. B. Kulkarni (*Agr. Jour. of India*, XVI, 388) gives an account of the importance of the grass *Andropogon purpureo-sericeus* in the Bombay Deccan. D. Clouston and F. J. Plymen (*Agr. Jour. of India*, XV, 380) have published an interesting paper on the principal fodders of the Central Provinces including the small bamboo (*Dendrocalamus strictus*). This plant promises to be a most useful fodder on poor light soils which cannot be irrigated. From the outturns already obtained, there is reason to believe that yields of from 40 to 60 tons of leaf per acre can be obtained from this variety of bamboo three years after planting. The authors state that "it should be possible in parts of India where tracts of poor land are available and where the rainfall is suitable, to establish bamboo fodder reserves from which useful supplies of green fodder could be obtained for seven or eight months of the year and from which bamboo hay could be made for utilization in years of fodder famine."

BOTANY

II.—Economic Botany

Part II.—Forest Botany

BY

R. S. HOLE, C.I.E., F.C.H.,
Forest Botanist.

Oecology of Sal.—The result of the sowings made in June 1920, in the local Dehra Dun forests, has supported the results obtained in previous years, *viz.*, that sowings in small clearings are more successful than sowings under partial or complete overhead cover. The development of the older seedlings, also, has now clearly demonstrated the fact that, by artificial sowings in these clearings, seedlings can be raised in the local forests with little or no dying back and which attain a height of 6 feet in 6-7 years. A factor which has assumed some importance during the year with reference to the development of these older seedlings is the damage done by rats and porcupines which destroy a number of vigorous young seedlings by eating through the sappy tap-roots. It is believed that this kind of damage will be relatively unimportant when work is carried out on a larger scale and the supply of vigorous young seedlings is greatly increased. A very similar state of things has been noticed in the case of damage to the seed. In bad seed years when very little seed is available in the local forests, porcupines and other animals destroy a large proportion of the seed in the artificially sown areas, whereas in good seed years practically no damage is done. The main principle which has emerged from the work done up to date on this subject is that, in order to accelerate the growth and establishment of sal seedlings, it is necessary to secure, as far as possible, favourable conditions of soil-moisture and soil-aeration throughout the year, that these conditions can often be greatly improved by making small clearings, with a suitable arrangement and degree of side-shade, and by raising the seedlings in these open areas instead of under the shade of the forest.

In this way, favourable conditions of moisture and soil-aeration can be secured, dense and vigorous weed growth is not produced, frost damage is avoided and the soil surface does not become injuriously hardened or compacted. Whatever the precise systems of management may be which are ultimately adopted to suit the local conditions prevailing in the various types of sal forest, it is probable that increasing attention will be paid to the importance of this principle in the Indian Working Plans of the future.

It is satisfactory to note that the Conservator of Working Plans in the United Provinces has now agreed to test the suggested group-*cum*-strip system of regeneration, experimentally, on a larger scale than has been possible up to date.

Local officers in the United Provinces have also initiated large scale experiments with the object of determining the best way of applying the principle in question to sal forests which are managed under the uniform method of treatment.

Oecology of Teak.—In 1916 the Forest Botanist published the results of experiments which showed that clear felling had a decidedly favourable effect on the germination of the seed and on the development of the seedlings of teak (*Indian Forester*, XLII, pp. 51-57). During the year this matter has again received attention in an interesting article by the Hon'ble Mr. J. W. Best in the *Indian Forester*, XLVI, pp. 411-415, where the opinion is expressed with reference to teak plantations in Berar that "clear felling in strips is likely to lead to the best results." There is little doubt that the principles which have been found to apply to sal will also be found to apply to a considerable extent to teak, also, and it is believed that there is considerable scope now in India for oecologists working in co-operation with forest officers, in devising improved methods of treatment for many of our important species, the seedling growth of which is, at present, often unsatisfactory and very slow.

Root Disease of Sal.—Caused by *Polyporus Shoreæ*. In co-operation with Dr. Shaw of Pusa a number of healthy sal saplings at Dehra Dun were inoculated with *Polyporus Shoreæ* in 1916 by the Assistant Forest Botanist, Mr. Abdul Hafiz Khan. During the year under report, several of these saplings were dug up and examined. The results so far obtained indicate that, while the fungus is unable to attack a healthy unwounded root, successful inoculations were invariably obtained when the mycelium was placed in contact with the wood in the interior of the root by means of a wound. It is interesting to note that Mr. W. E. Hiley, in his recent work on the larch in the United Kingdom, has come to the conclusion that good soil-aeration is of great importance for that species and that the fungus *Fomes annosus* gains an entrance into this tree through roots which have been killed by bad soil-aeration (*Fungal Diseases of the common Larch*. Oxford, 1919, p. 184). It is probable that the most effective means of controlling troublesome root diseases such as that of the sal mentioned above and that of *Dalbergia Sissoo* caused by *Fomes lucidus* will consist in improved methods of treatment which will ensure a better water-supply and condition of soil-aeration.

The Forest Botanist attended the conference of mycologists at Pusa in February and read a paper on the physiology of disease.

Systematic.—The Forest Botanist, while on leave, studied the material in the Kew herbarium of the genus *Tamarix*. Mr. H. H. Haines continued work on the Forest Flora of Bihar and Orissa and the following publications are under preparation :—

A revised edition of the *Forest Flora of the Punjab* by Mr. R. N. Parker, a *Forest Flora and Descriptive Lists for Assam* by Rai Bahadur Upendranath Kanjilal and *Descriptive Lists* for the United Provinces by Messrs. A. E. Osmaston and P. C. Kanjilal. Mr. C. E. Parkinson has completed his draft of the *Forest Flora of the Andamans*. A new species belonging to a new genus *Dioticarpus Barryi* Dunn was discovered by Mr. D. T. Barry in Tinnevelly.

BOTANY

II.—ECONOMIC BOTANY

Part III.—Mycology

BY

F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S.,

Officiating Imperial Mycologist.

Agricultural Research Institute, Pusa.—The following is an account of the chief investigations carried out at Pusa during the year :—

Cereal diseases.—The study of the genus *Helminthosporium* on cereals and sugarcane was continued by Mr. M. Mitra. The cultural study of the species found on maize, jowar, sugarcane, rice, wheat, and barley was completed. All these, together with the four strains on wheat, were cultivated on a large number of media of different chemical constituents, and also on sterilised straw of paddy and wheat. They were also kept at different temperatures. No perfect stage of any of them was discovered. Some of the species kept constant characters in a particular media, even when grown on it repeatedly, but others such as *H. teres* Sacc. on barley, *Helminthosporium* on wheat from Pusa and Burma, and *Helminthosporium* on sugarcane showed occasional changes in the character of growth and also in the size of spores formed. Thus *H. teres* Sacc. of barley has sometimes a dark growth, sometimes a snowy white and wooly growth and occasionally a pinkish white growth. Similarly *H. Sacchari* Butl. generally produces a good aerial growth but sometimes a subculture gives a creeping dark mycelium full of spores and with very little aerial growth. Again a subculture from this may give rise to an aerial growth, or may keep the character of the parent culture for some time and then again revert to its old habit. Spores are also variable in size. *H. teres* Sacc. on barley produces pycnidia and chlamydospores on sterilised wheat straw. The latter have not been described before.

The study of *Helminthosporium* on maize and jowar was concluded. The species on maize and jowar appears to be two different strains of *H. turcicum* Pass. It is interesting to note that *Helminthosporium* is found on maize only, and not on jowar, in Bihar, and *vice versa* in the Punjab. From the results of cross-inoculations it is concluded that there is no specialisation of parasitism and that the fungus from one host can infect others. Thus cross-inoculations

with *Helminthosporium* on maize and jowar give reciprocal results and infections are also successful on sugarcane, wheat, barley, oat and to some extent on rice, but not on bajra. Rice and sugarcane *Helminthosporium* give positive results when cross-inoculated on maize, jowar, wheat, oat, barley, rice and sugarcane. All the four strains on wheat give positive results on rice, maize, jowar, oat and barley and some also on sugarcane. *H. teres* Sacc. which does a good deal of damage to barley in Pusa was inoculated with success on wheat, maize, rice, jowar and oat.

Helminthosporium on wheat, one of the causes of " Foot rot," was obtained from America and is being compared in culture with the forms on wheat and barley occurring in Pusa. On sterilised wheat straw, it agrees very much with *H. teres* Sacc. on barley and on wheat in Pusa. *Helminthosporium* on barley and oat does good deal of damage to seedlings and young plants. Last year it was present to a large extent on oats. It is intended to try control measures by treating the seeds before sowing.

Acrothecium lunatum Wakker has been found on *Setaria italica* Beauv., Sawan (*Panicum frumentaceum* Roxb.) and *Eleusine coracana* Gaertn. It forms small elliptical or elongated brownish or straw colour spots but it is not very common. It occurs on many other plants also and appears to be a weak parasite. A memoir was published on *Acrothecium Penniseti* n. sp. on bajra.

Miscellaneous.—The research work on diseases of paddy caused by *Piricularia* was continued by Mr. McRae. The results of Mr. Dastur's work on *Choanephora* and Anthracnose of chilli were published during the year under review and a paper dealing with "die back " of chillies (*Capsicum* spp.) in Bihar is in the press. A paper on the mode of infection of sugarcane with smut was published and the causes of the immunity of thick canes to this disease are being studied in the light of this new information.

The bud rot disease of palmyra palms, which has long been one of the major fungal diseases of Madras, appeared in the Burdwan district of Bengal. This new outbreak and a disease of areca palms in Assam, is being investigated. *Urocystis coralloides* Rostrup a rare smut on mustard was discovered for the first time in India in the vicinity of Pusa and was identified at the recently created Imperial Bureau of Mycology.

Other Scientific Departments.

Madras.—The operations against the bud rot of palmyra palms were continued under the new Pest Act by which owners are compelled to cut down dead trees. The results obtained during the past year showed an improvement on preceding years—the number of dead and outwardly infected trees being reduced. The appearance of this disease in Bengal, and the question whether infection reached Bengal from the Godavari, has to be investigated. Spraying of grape vines against mildew was extended during the past year with most beneficial results, the yield from 239 vines

rising from Rs. 710 to Rs. 3,950. Spraying was also carried out against the mahali disease of areca-nuts. The intensity of this disease appears to be waning.

Seed treatment against the smut diseases of cholam (*Sorghum vulgare*) and tenai (*Setaria italica*) was carried out in Bellary, Kurnool and Anantapur. Approximately 32,000 acres were sown with treated seed and the decreased incidence of disease may be estimated to have resulted in a gain of about Rs. 100,000 to the cultivator.

The treatment of " bleeding disease " of coconuts, by surgical excision of the diseased tissue and flaming and tarring the exposed surface, proved successful and was introduced among garden owners in the coconut growing areas.

Other diseases under investigation are a disease of ginger caused by *Vermicularia*, the long smut (*Tolyposporium filiferum*) of cholam and the green ear disease of cumbu (*Pennisetum typhoideum*). A paper on the *Helminthosporium* disease of paddy is in the press. This disease appears to be of minor importance and only causes serious damage under conditions which are favourable to the development of the fungus.

Bombay.—Various smut diseases were investigated. Experiments with smut on *Eleusine coracana* failed to afford proof that the disease was carried on the seed. Smut on *Panicum frumentaceum*, however, proved to be seed borne and will probably yield to the usual seed steeping in copper sulphate. A variety of *Sorghum*, known as " milo," which is reported to be resistant to smut in America, proved to be very susceptible to Loose Smut (*Sphacelotheca Cruenti* Kuhn Pot.). A powdery mildew (*Oidiopsis*) was found attacking the potato crop in Khed and Chakan. Other new diseases were caused by a species of *Synchytrium*, parasitic on betel vine, and a species of *Diplodia* attacking the camphor tree. Sugarcane in certain areas developed a suspicious mottling of the leaf but so far the early suspicions of mosaic disease have not been confirmed.

Bengal.—Ufra disease of paddy was not severe anywhere in Eastern Bengal during the year under review. Sugarcane suffered from " red rot " (*Colletotrichum falcatum* Went) at Charnagardi and demonstrations of sett selection were given. Experiments in spraying against die-back (*Vermicularia Capsici*) of chilli were carried out in Rajbari and liming the soil as a remedy against wither tip (*Colletotrichum gloeosporoides*) was attempted at Kalimpong.

United Provinces.—Some preliminary experiment on storage rot in potatoes were carried out and operations against red rot of sugarcane were instituted at Gorakhpur. Further work was impossible in the absence of equipment in the new mycological section.

Central Provinces.—Investigations on wilt disease in cotton were commenced and two strains of a *Fusarium* were isolated.

Indian Tea Association.—The research work was mostly confined to leaf diseases. Articles on Brown blight (*Glomerella cingulata* (Stonem) S. & V. S.) and Grey blight (*Pestalozzia Theae* (Sawada) have been published in the Quarterly Journals of the Department. An article on Copper blight (*Laestadia Camelliae*, Cke) has been prepared for publication.

Some experiments were made to determine the vitality of the conidiospores of *Glomerella cingulata* (Stonem) S. & V. S. and the pycnospores of *Laestadia Camelliae*, Cke. It was found that the pycnospores of *Laestadia Camelliae*, Cke in spite of their thick coat were only able to survive about a week when kept in the shade under the laboratory conditions of humidity and temperature. The conidiospores of *Glomerella cingulata* (Stonem) S. & V. S. only survived 1 day.

A species of *Colletötrichum* was isolated from the root of a dead tea bush.

A species of *Nectria*, found in some Cankerous tea stems, was investigated.

AGRICULTURAL BACTERIOLOGY

BY

J. H. WALTON, M.A., M.Sc.,

Officiating Imperial Agricultural Bacteriologist,

WORK AT PUSA.

Soil Biology.

Nitrogen.—Estimation of losses of nitrogen from cattle dung and urine stored under either ærobic or anærobic conditions show the necessity of anærobic storage for proper conservation of the nitrogen of the urine. Only fifteen per cent of the urine nitrogen was lost under anærobic conditions compared with eighty-five per cent under ærobic conditions.

Further experiments on the nitrification of mahua cake have been carried out. Composting the cake with rock phosphate and sulphur for four weeks has resulted in 25 per cent of the nitrogen of the cake becoming nitrifiable.

Indigo.

A simple colour test has been devised by Mr. W. A. Davis, the Indigo Research Chemist, by which the proper time of steeping the plant can be ascertained. An important factor in causing variations in the length of steeping required to give the best produce, quantity and quality both being considered, is the bacterial flora of the steeping water. Until Mr. Davis's test was employed, unsatisfactory results had been obtained with steeping water, inoculated with a pure bacterial culture that had worked well in the laboratory, both with and without sterilisation of the water before addition of the pure culture. When the steeping time was controlled by use of the test the first day's working gave produce of 78·5 per cent quality. The steeping water was first sterilised with E. C. the hypochlorite preparation made at Pusa and after 12 hours, inoculated with a culture isolated from water in Assam. Indigo of this high quality will prove of value for mixing with lower grades, for the manufacture of 20 per cent indigo paste for the far eastern market.

Detailed studies of the cultural characters and efficiency of indigo hydrolysing bacteria from various sources have been carried out in the laboratory.

Plant Diseases.

A bacterial rot of potatoes sent from Assam was investigated.

Work in the Provinces.

Biological studies of typical soils were carried on in the Central Provinces, Madras, and by the Indian Tea Association at Tocklai, Assam. In each of the soil types investigated at Tocklai, the soil optimum moisture for the best mechanical condition was the optimum for nitrate accumulation and carbon dioxide formation.

The decomposition of green manure plants at different stages of growth in the black cotton soil of the Central Provinces was investigated.

It was found that the earlier the stage of growth at which "sann" is used as a green manure, the more rapid are the processes of nitrification and the decomposition of carbonaceous substances. In the case of Dhaincha, there is no marked decrease in the rate of nitrification with the increasing age of the plant.

In the black cotton soil the stems of sann hemp did not retard the decomposition of the leaves, which is contrary to their effect in Pusa soil.

FORESTRY

Part I.—Silviculture

BY

S. H. HOWARD, B.A.,

Silviculturist.

The year under report is for nine months only owing to the recent change in the forest year which now coincides with the financial year. This report therefore can hardly be regarded as normal, especially as a large amount of work takes place between April and June none of which is included in this.

Perhaps one of the most important matters to comment on is that an efficient division of labour between the Local and Central Silviculturists is becoming more defined. It is beginning to be abundantly clear that the main division of labour will eventually be that Local Silviculturists will concern themselves more with experimental silviculture, pure and simple, while the Central Institute will control statistical work and be a general bureau of information. Bengal and Burma have, during the year, laid out the main lines of policy to be pursued in silvicultural research and it is hoped that other provinces will follow suit in the near future and appoint Local Silviculturists.

Statistical work.—A good many plots have been remeasured and a certain number of new plots have been laid out both by the Central Institute and by the Local Silviculturists. The new methods of calculation have now been finally adopted and a large portion of the former work has been converted to them. Data are as yet insufficient to publish proper yield tables but for certain species the time is rapidly approaching when approximate yield tables can be issued. When the policy of this work has been strictly laid down it should be possible to produce yield tables for several of the principal species and volume and form factor tables for others within the next five years provided staff is forthcoming. Owing to press difficulties the only statistical publication which has appeared is an article on Sal taper curves by E. A. Smythies and S. H. Howard in the Indian Forester but the following are in press:—

(1) Note on weights of seeds by S. H. Howard, B.A.

(2) Note on the rate of growth of Bengal Sal by S. H. Howard, B.A.

(3) A code for the collection and compilation of statistical data with Appendices by S. H. Howard, B.A.

(4) The Forest Pocket Book by the United Provinces Research Branch which contains various statistical data.

The Sal (Shorea robusta).—A good deal of experimental work was commenced in the United Provinces and in the Central Provinces on the natural reproduction of Sal, the cover being opened to various degrees and the ground cover being burnt or unburnt. Strip fellings, and ordinary clear fellings to let up established seedlings, both with and without burning of the slash, were tried by the United Provinces and Central Institute but there has been insufficient time at present to formulate definite opinions. An experiment in the Bengal taungya methods was projected in Dehra Dun but owing to no suitable arrangements having been made it had to be abandoned.

Various other minor experiments are in progress and the experiment on storing seed, commenced last year, gave promising results and will be repeated this year on a larger scale.

At present the problem of Sal regeneration is still unsolved in most districts.

Afforestation.—The experiments indicated for Zabarkhet in last year's report have as yet (March 31st, 1921) had no time to show any result except in the case of the Chir. Both in the ploughed lines and on the cleared ground this germinated well, has withstood the frost and looks promising. The afforestation area will be extended next year.

Many experiments have been made by the United Provinces in the Bhabar with various species. It has been conclusively shown that root and shoot cuttings of Sissoo (*Dalbergia Sissoo*) are a simple and effective method of afforestation even in lantana areas with no weedings if planted early and irrigated, but unfortunately irrigation is usually impracticable. It is hoped that the Zabarkhet method of winter planting with root and shoot cuttings will prove next year that the afforestation can be done in this way in grass areas with neither weeding nor irrigation.

Experiments with other species in the United Provinces have so far only shown again that weeding in the first rains is essential.

Work has been done by other provinces but up to date no conclusions have been reached.

Mr. Smythies brought out his Afforestation of the Jumna Ravines in Etawah (Indian Forest Record, Vol. VII, Part VIII). This is now being published in Urdu and Hindi. Mr. Benskin's book "Afforestation in the United Provinces" has been sent to Press.

Experimental Silviculture.—It is quite impossible to give any idea of the volume of work which has been done this year by the various provinces in a report of this length and reference is invited to Annual Report of Forest Research work in India. In most cases it is only the commencement of the work and no important results have as yet been obtained.

The camphor experiments have now yielded sufficient data and it is hoped to bring out a publication in the near future.

Mr. Champion's work on twisted fibre in Chir is being continued.

Two small interesting points reported from Behar and Orissa are worthy of notice., *viz.*, that Casuarina is highly susceptible to any maltreatment of the taproot and that teak seed burried in the soil, covered with alternate layers of straw and watered regularly for a fortnight produced much healthier and stronger seedlings than seed merely soaked for 48 hours prior to sowing.

Many other provinces furnished a mass of information too detailed to be reproduced here.

Development in Silvicultural Systems.—There is nothing special to report this year. Burma and Bengal continued to develop the taungya system of regeneration and extremely fine results are being obtained in both provinces. Up to date working plans are being rapidly compiled wherever staff and money is available. The improvement in the standard of working plans in the United Provinces since the creation of the Working Plans and Research Circle is most noticeable and Burma has now followed suit by creating a Working Plans Circle though there has as yet (March 31st, 1921) been insufficient time to see the good effects from this.

It can be confidently asserted however that other provinces must follow suit and create these special circles if their plans are to attain that standard which they should attain now-a-days.

Miscellaneous.—Though this report deals with only nine months it is surprising the amount of new work which has been done. There is no doubt that this is largely due to the appointment of Local Silviculturists and the standard of experimental work in those provinces where they exist is most noticeable. It is however becoming increasingly evident that the same high standard is not being attained in the statistical work. The compilation of statistical data is likely to become far more centralised in the near future.

FORESTRY

Part II.—Economic Forest Products

BY

R. S. PEARSON, C.I.E., I.F.S.,

Forest Economist.

Considerable progress in the preparations for the expansion of the Economic Branch was made during the year. The staff was strengthened by the arrival of specialists in Timber Testing and Seasoning, from Canada and America respectively, and Mr. Raitt, the officer-in-charge of all enquiries in connection with Paper Pulp, returned from deputation in England to take up his appointment as a whole-time officer at the Institute. A Wood Worker was also appointed and took up his duties. The timber testing machines and seasoning plant for which orders had been placed in America by the Forest Economist, in consultation with the officers concerned, arrived during the year and steps were taken immediately to erect most of the former in an existing workshop as a temporary measure pending their removal to the site on which the new workshops are shortly to be built. The erection of the seasoning kilns had to be postponed until the new site is ready owing to lack of space, but it is proposed to put up a temporary kiln in the Institute grounds for the purpose of giving demonstrations at the Forest Conference to be held in January 1922 and for seasoning the timber to be used in making furniture for the new Institute. A portion of the necessary wood working machinery was obtained in India and an experimental Rotary Veneer Cutting Machine and a Sawmill were purchased in America. All were received during the year. The up-to-date experimental paper and pulp plant, to arrange for which Mr. Raitt had been deputed to England in 1919-20, was manufactured during the year and despatched to India, and will be erected as soon as the new site is ready.

The staff has been chiefly engaged on organisation work in the respective sections, especially on designs and workshop lay-outs, and though this has taken up a very considerable portion of their time nevertheless new investigations have been started, especially in connection with timber testing, seasoning, paper pulp, minor forest products.

The Wood Technologist is due to arrive about January 1922 but the post of Wood Preservation Specialist, though sanctioned, has not been filled, as a suitable officer has not yet been found. A complete experimental antiseptic pressure plant was received from England which will be made use of when the buildings on the new site are ready.

Observation and encouragement of the Paper Pulp Industry in India and Burma.—The preliminary work to carry out new surveys of possible bamboo areas in Bihar and Orissa and Madras was undertaken and the Officer-in-charge also paid a visit to Burma in connection with grass pulp schemes. As soon as the machines are erected a complete series of tests on Savannah grasses will be carried out. A large number of enquiries on the question of utilising bamboo for paper pulp were dealt with by this section and advice on how to obtain technical training was frequently sought.

Antiseptic treatment of timber.—The experimental sleepers laid down from 7 to 10 years ago in open lines and treated by four different methods were inspected. Those laid in the line 10 years ago and treated by the Powellizing Process show that *Terminalia tomentosa* (Sain, Asna, Taukkhyan or Saj) are, with few exceptions, doing remarkably well. *Pinus longifolia* (Chir) and *Pinus excelsa* (Kail) are still doing well in dry localities, moderately so in damp and have all been rejected after from 9 to 10 years' service when placed in very damp localities. The two *Dipterocarps* (In and Kanyin) have lasted 10 years, the cause of rejection being deterioration under rail seat and around spike holes. Had both the *Pinus* and *Dipterocarps* been laid with bearing plates they would probably have lasted 2 or 3 years longer, bringing their life up to that of *Cedrus Deodara* (Deodar) or *Shorea robusta* (Sal) in similar localities. In the other experiments, treatment with Creosote and Earth Oil introduced in fairly large quantities has given better results than either treatment with a small quantity of high grade oil or treatment with Chloride of Zinc and Creosote. Several railways evinced increasing interest in these experiments and it is expected that a number of treating plants will be erected shortly. The results of the experiments are being prepared for the press.

Physical and Mechanical properties and seasoning powers of various timbers. (*i*) *Natural Seasoning.* The final inspection of the seasoning experiments in Bengal and the Central Provinces were carried out by the Officer-in-charge, Seasoning, and the results will be published in the near future.

(*ii*) *Artificial Seasoning.*—The apparatus for the four blower and three steam spray drying kilns is now coming to hand and it is hoped to erect the kilns next cold weather.

(*iii*) *Mechanical Properties of timber.*—The first tests being carried out on the new machines are on red and white wood of Spruce to determine its value for sleepers after impregnation. A complete project according to which tests on the more important Indian timbers will be undertaken is under preparation.

Finding of markets and new uses for timbers including the issue of bulletins.—A large number of enquiries from firms, both in India and abroad,

were replied to and bulletins on the following timbers were issued during the year :—

(1) *Dipterocarpus pilosus.*

(2) *Lagerstroemia Flos-Reginæ.*

Gums, Resins and Oleo-Resins.—The question of utilising the gum-oleo-resin of *Boswellia serrata* (Salai) was advanced a step further by the publication of Dr. Fowler's valuable note on the work he had carried out at the Indian Institute of Science, Bangalore. His process differs from that advocated by Mr. Puran Singh in that alcohol is not used as a solvent. The Gwalior State are about to erect a plant working by the solvent process, the results of which will be watched with great interest.

Rosha grass oil.—The steam distillation of Rosha grass oil is now carried on successfully as a commercial undertaking in the Central Provinces and the industry is likely to expand.

Tanstuffs.—The Officer-in-charge carried out a detailed investigation on tanstuffs in the Sunderbans, completing 80 analyses of various products in that locality, the results of which are given in his report entitled "Tanstuffs of the Sunderbans Forest Division" and published by the Department of Industries, Bengal. The Officer subsequently proceeded to North Burma and carried out analyses of Chestnut, Oak, *Dipterocarp* and other timbers, barks, fruits and leaves, the results of which indicate considerable possibilities of working them commercially.

Charcoal Briquettes.—Investigations have been continued in consultation with an American Briquetting firm to whom a consignment of 500 lbs. of charcoal and 100 lbs. of binding material has been sent for experiments. The main difficulty to be overcome is to devise a process of grinding the charcoal without undue danger of combustion taking place.

Woods suitable for :—(*i*) *Bobbins, Shuttles and Picking Sticks for Cotton and Jute Mills.*—Nearly 5,000 sample pieces of the following species :—

I. *Odina Wodier.*
II. *Albizzia procera.*
III. *Adina cordifolia.*
IV. *Wrightia tinctoria.*
V. *Holoptelea integrifolia*
VI. *Stephegyne parvifolia.*
VII. *Michelia Champaca.*
VIII. *Stereospermum xylocarpum.*
IX. *Stereospermum chelonoides.*
X. *Anogeissus latifolia.*
XI. *Dyospyros macrophylla.*

XII. *Lagerstroemia tomentosa.*

XIII. *Dillenia pentagyne.*

XIV. *Polyantha ceracoides.*

XV. *Garcinia Morella.*

XVI. *Homalium tomentosum.*

were collected and sent to a leading firm in England for trial after they had been put through the seasoning kiln at Bareilly, which has kindly been placed at our disposal by the Conservator, Utilization Circle, until the kilns at Dehra Dun are ready.

(*ii*) *Ply woods.*—A visit was paid to the leading firms and it is satisfactory to note that the tendency to " cheesiness " in certain timbers referred to last year has been overcome and the prospects of the industry developing in India are bright.

ZOOLOGY

I.—GENERAL ZOOLOGY AND PHYSICAL ANTHROPOLOGY

BY

S. W. KEMP, D.Sc., F.A.S.B.,

Officiating Director, Zoological Survey of India.

Tours.—The following tours were undertaken by members of the department :—

	Days.
To Bombay from 7th April to 18th April 1920 by Major R. B. Seymour Sewell	12
„ Barkuda from 24th April to 1st May 1920 by Major R. B. Seymour Sewell	8
„ Simla from 14th May to 22nd May 1920 by Dr. N. Annandale	9
„ Barkuda from 17th June to 28th June 1920 by Dr. Baini Prashad	12
„ Barkuda from 13th August to 22nd August 1920 by Dr. N. Annandale	10
„ Naini Tal, Moradabad, Delhi from 31st July to 2nd September 1920 by Dr. Baini Prashad	34
„ Barkuda from 22nd September to 27th September 1920 by Dr. N. Annandale	6
„ Barkuda from 22nd September to 27th September 1920 by Dr. Baini Prashad	6
„ Delhi from 18th December to 25th December 1920 by Dr. S. W. Kemp	8
„ Waltair from 19th January to 29th January 1921 by Dr. S. W. Kemp	11
„ Port Blair from 12th February to 20th March 1921 by Dr. S. W. Kemp	37
	153

Dr. Baini Prashad's tour to Naini Tal and Moradabad was undertaken in continuation of the survey of the freshwater molluscs which is being made at the request of the medical authorities. Barkuda island was visited on a number of occasions in order to carry out experiments in the intensive study of the fauna of a small localised area.

Dr. Kemp's visit to Port Blair was undertaken in order to discuss the establishment of the proposed Marine Biological Station with the Chief Commissioner of the Andaman and Nicobar Islands and to select a site.

Publications.—The following publications have been issued during the year :—

"Records of the Indian Museum," Vol. XVII.

"Records of the Indian Museum," Vol. XVIII, parts III—V.

"Records of the Indian Museum," Vol. XIX, parts II—V.

"Records of the Indian Museum," Vol. XX.

"Memoirs of the Indian Museum," Vol. V, Nos. 7 & 8.

Library.—The total additions to the library number 1538. Of this number 826 books and parts of periodicals were received in exchange, 583 were purchased and the remainder presented.

Collections.—The collections have remained in good condition and numerous additions have been made to them apart from those obtained by the officers of the Survey themselves.

Valuable collections of Crustacea have been obtained by exchange from the British Museum and from the museums at Paris, Cambridge and Milan. Professor Max Weber has sent us a duplicate set of the Molluscs which he obtained in his Expedition to the Dutch East Indies and a valuable collection of shells has also been obtained by purchase from Lieutenant-Colonel H. H. Godwin Austen, F.R.S.

Additions to the insect section include a number of valuable specimens presented by Major F. B. Scott, Mr. C. J. Drake and Major F. de Mello.

Our collection of hill-stream fishes belonging to the genus *Discognathus*, which had been lying with Dr. Pitschmann in Vienna since before the beginning of the war, has now been returned. A collection of flies belonging to the family Dolichopodidae which had been in Germany throughout the period of the war has also been received back.

Galleries.—The Invertebrate Gallery still remains closed but it is hoped that half of it will be refitted and opened to the public during the course of the next financial year. Owing to the present high price of plate glass it has been difficult to complete the alterations in this gallery expeditiously.

To the Ethnological Gallery a number of specimens from Manipur and Baroda States have been added. A special collection from the Nicobar Islands was made and presented by Mr. H. Hart making the exhibit of the ethnology of these Islands almost complete.

ZOOLOGY

II.—ECONOMIC ZOOLOGY

Part I.—Agricultural Entomology

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist.

It should be noted that, in compliance with orders of Government that the Report on Agricultural Entomology in India during the year ended 30th June 1921, should not exceed four pages, exclusive of bibliography, only a very brief summary of the work done at Pusa and in the Provinces can be given here.

I.—Work at Pusa.

Numerous observations on Insect Pests were made and a fuller account of these will be found in the Scientific Report of the Pusa Research Institute for this year. Investigations were continued on pests of cotton, rice, sugarcane and other gramineous crops, fruit and stored grain. Life histories of numerous insects have been worked out and illustrations prepared. Work on Bees, Lac and Silk was continued on previous lines. Steady progress was made in the additions to and arrangement and identification of the collection. The scheme for the preparation and publication of a catalogue of Indian insects has been approved and is being pressed on. The Fourth Entomological Meeting, held at Pusa from 7th to 12th February 1921, was attended by over forty members who contributed fifty papers which are being issued in the Report of the Meeting.

II.—Work in the Provinces.

Madras.—Attention was mainly devoted to the study of *Platyedra gossypiella*, *Pempheres affinis* and *Schœnobius bipunctifer*. The rate of increase of *P. gossypiella* in green cotton bolls and the comparison of the percentage of attack of areas under the Pest Act as compared with those outside its jurisdiction were studied, with the result that a notable decrease was found in the Pest Act area. The study of *P. affinis* was continued in connection with the intensity of attack in different strains of Cambodia cotton; the natural enemies were found to include a Braconid parasite and a fungus. Experiments with the control of *S. bipunctifer* in the Kistna district were continued and gave

satisfactory results. The study of *Yerra tegelu*, a mysterious disease of paddy in the Godavari delta, was taken up. Other pests dealt with included *Spodoptera mauritia* on paddy in Malabar and Capsid bugs attacking cotton.

Bombay.—Demonstrations and lectures on control of pests were given in Gujarat. Investigations of granary pests and of their parasites were made. Experimental work was also done on control of Hairy Caterpillars, *Juar* stem-borers (*Chilo simplex* and *Sesamia inferens*), cotton-pests, surface grasshoppers (*Chrotogonus* spp.), *Urentius echinus* on brinjal, pests of *tarwad* [apparently *Sesbania* sp.] and cattle ticks.

Central Provinces.—Rearing of wood-borers in mango, *Lagerstræmia indica*, *Zizyphus jujuba*, *Ficus religiosa* and *Phyllanthus emblica* showed that both "*Arbela*" *tetraonis* and *A. quadrinotata* were present. Observations of the occurrence of *Carpomyia vesuviana* and *Meridarchis scyrodes* in *ber* fruits showed that the pupal stages of both these insects may be prolonged for several months in the hot weather. Obervations were made on the parasitization of *Sphenoptera gossypii* by *Xanthopimpla punctata*. Study of the insect fauna of weeds was continued. A small undetermined weevil was reared from flowers of *Zizyphus jujuba*.

United Provinces.—The main work has been the investigation of cotton pests and has been preliminary to a study of *Platyedra gossypiella* and other pests of cotton. Some attention has also been paid to pests of sugarcane and mango.

Punjab.—The percentage of bollworm attack on cotton was not very high this year and in most places was below normal. The life history of *Microbracon* sp., parasitic on *Earias*, was studied and it was found that a single female may lay over 200 eggs, the life-cycle being completed in about ten days in summer, lengthened to 30 days in winter. The life history and control of mango-hoppers (*Idiocerus atkinsoni* and *I. clypealis*) were studied and winter spraying with a strong contact poison was found effective. Spraying operations with tobacco decoction or crude oil emulsion were found effective against *Euphalerus citri*, on Citrus trees, and are becoming very popular. Some work has also been done on control of rats, mainly by the use of strychnine. Experiments were carried out to test the efficacy of the use of heat for the control of granary pests. Sericultural work has been continued and 1750 ounces of eggs were under rearing in 1921, as compared with 600 ounces in 1920; unfortunately, the unusually hot season killed off most of the worms at the time of spinning their cocoons.

Bihar and Orissa.—Work on the Braconid parasite of *Agrotis ypsilon* was continued on the lines of (1) breeding the parasite through the hot weather and Rains, and (2) ascertaining the factors which may be utilized in inducing dormancy in freshly-formed cocoons. As a result it has been found impossible to carry this parasite on in an active condition in the Plains in the absence of a cool room, and that freshly-formed pupæ, when exposed to a constant humidity of 5°, at once become dormant and remain healthy until revived by

exposure to favourable conditions of temparature and moisture. A large number of pupæ is being kept this summer for experiment and use at the beginning of the cold weather.

Bengal.—The use of cloth bags, to protect young mango fruits before egg-laying of the weevil, was found successful against *Cryptorrhynchus gravis* in the case of small trees of valuable fruits, which are worth the cost and trouble. Control work was done against *Arbela tertaonis*, Litchi Mite, and *Brachytrypes portentosus*.

Assam.—Work was done on the control of rice pests (*Hispa armigera*, *Leptocorisa varicornis* and *Schœnobius bipunctifer*). Serious damage by *Hispa* occurred in an extensive area near Srimangal, whilst there was an unusually severe attack of Rice Grasshopper in the neighbourhood of Hajo. *Diacrisia obliqua* attacked pulse, crops and jute.

Burma.—Investigation of *gwabo*, a disease causing yellowness in growing paddy and empty grains in a part or whole of the ear, was commenced, but only about 5 to 8 infestation by borers was found. The borers found in rice prove to be *Schœnobius bipunctifer*, *Sesmia inferens* and *Diatræa* sp. (Pusa, C. S.-1674), of which the first-named is the most important. At Hmawbi where paddy selection work is being carried on, some varieties showed markedly greater infestation than others, thus indicating that some varieties are more resistant to insect attack. *Hispa armigera* occurred in Kyaukse district in June and was found only on Ngasein paddy. The main damage to sugar-cane in Upper Burma appears due to Termites. *Andropogon sorghum* is quite free from borers at Mandalay, apparently due to the absence of *Chilo simplex* in Burma. The main pest of cotton is *Platyedra gossypiella*. *Oryctes rhinoceros* was under investigation, the grubs breeding chiefly in the village manure heaps. Fruit-flies in peaches and pears at Maymyo do serious damage, apparently due to a complete absence of parasites.

III.—Native States.

Travancore.—*Nephantis serinopa* on coconut was the most important pest of the year and was dealt with by cutting and burning the affected leaves, the Pest Act being enforced and more than 35,000 trees treated. The method of control of *Leptocorisa varicornis* on rice, by bagging the bugs, was demonstrated with success. Pests of ginger were also under observation and a species of *Calobata*, boring in the rhizome is stated to be very destructive.

Mysore.—Field-work against *Amsacta albistriga* and *Discrisia obliqua* has been continued; against the former the Pest Act has been continued to be enforced over a considerable area with satisfactory results. Field-work on the control of *Xylotrechus quadripes*, on coffee, by painting the stems with Brunolineum just after oviposition, has yielded successful results. Control of *Oryctes rhinoceros* has been carried out on an extensive scale in a Government Date Reserve, by destruction of rotting stumps and of the larvæ found in manure pits. Parasites of mangoleaf-hoppers have been under investi-

gation and their life histories worked out. Work has also been done on cane borers, *Juar* Cecidomyiad, *Spodoptera mauritia* and *Chloridolum alcmene*.

Hyderabad.—
Kashmir.— } No scientific work is reported.
Baroda.—

IV.—Other Entomological Work.

Indian Tea Association.—The attention of the entomological branch was devoted to further investigations into the control of "mosquito blight" (*Helopeltis theivora*, Waterh.). Experiments on the inoculation of bushes were carried out on an extensive scale in all districts and have confirmed the result, previously obtained, that inoculation of the bush with salts of potash gives a decided increase to the resisting power of the bush to attack. The manuring experiments have also shown that the degree of resistance to attack can be altered by manuring, but that whereas bushes on different types of soil respond similarly to direct inoculation with potash, the results obtained from manurial applications differ with the type of soil.

Observation of cases where the intensity of attack differs greatly on areas on the same soil, but under different management have afforded evidence that bushes on the same soil will differ in liability to attack when the soil is treated differently, this difference in degree of liability to attack being correlated with an increased proportion of potash in the growing leaf, and examination of bushes throwing off attack has shown that this increasing resistance is accompained by a distinct increase in the proportion of potash present in the growing leaf.

Breeding records have been kept throughout the year in connection with the green fly pest of tea (*Empoasca flavescens*, Dist.).

South Indian Planting Districts.—No work on Entomology was carried out.

ZOOLOGY

II.—ECONOMIC ZOOLOGY

Part II.—Forest Entomology

BY

C. F. C. BEESON, M.A., I.F.S., F.E.S.,

Forest Zoologist.

Insects of Sal.—Borers (*a*) *Field work.*—In the area of the epidemic occurrence of *Hoplocerambyx spinicornis* in Thano Forests, Dehra Dun, observations were continued on the plan of previous years involving enumerations and plane-table surveys. Particular attention was paid both in the insectary and field to the effects of edaphic and climatic conditions on the incidence of the borer, which is now correlated with rainfall. The recognition of a connection between the periodic abundance of the borer, the resistance of the host tree to attack and rainfall during the flight period of the beetles, has materially altered existing conceptions of the economic status of the pest. It is now apparent that in a series of years of high rainfall, the increase of the borer is favoured and the resistance of the host tree is lowered; in years of low rainfall the reverse effect occurs. If the monsoon fails during the course of a borer epidemic the proportion of trees fatally attacked is reduced (in spite of the relatively increased incidence of the borer) to such an extent that the pest receives a marked check. Control measures based on above results have been formulated and put into practice during the 1920-21 season. It is anticipated that given a valuation of the growing stock and its increment, a safety limit expressed in deaths per acre and a safety period for control operations can be determined. A note on the connection of *Hoplocerambyx* with the dying off of sal has been published in the Indian Forester for February 1921.

In tours made in Singhbhum and Porahat Divisions, Bihar and Orissa, it was determined that *Hoplocerambyx* is rare or absent in dry and hill type sal forests, and that it is usually a secondary effect of *Polyporus shoreæ* in the moist and valley type sal; a condition suspected some years before in the Bengal Duars forests. The frequent mortality of sal without the assistance of borer attack leads one to consider that borers of the type of *Hoplocerambyx* are essentially secondary factors, which however under epidemic conditions may determine the death or survival of a weakened tree.

(*b*) *Insectary work.*—Further insectary records of the development of *Aeolesthes holosericea*; *Xylotrechus smei*; *Platypus* spp; *Diapus* spp. and *Xyleborus* spp. have contributed to the establishment of the economic status of these species and revealed the extent to which their prevalence is affected by climber-cuttings and girdling or felling without removal of inferior species.

Other pests.—The seed weevil, *Calandra shoreæ*, has been found to have a wide distribution and a variety of dipterocarp host-plants.

Insects of the teak.—Work on the collection of further statistical data on the beehole borer, *Duomitus ceramicus*, has been in abeyance. Further records of the minor sap-wood borers and shot-hole beetles have been obtained in the insectary.

Miscellaneous pests.—During the year under report 125 consignments of specimens (including 903 insects) were received for investigation. The determination of the borer fauna of timbers seasoned by various natural processes received attention. A total of 910 pieces of timbers has been received from divisions and some 8,500 insect specimens have been bred out, adding considerably to our information on the food trees and distribution of timber pests.

A short survey was made in the Sunderbans, Bengal, of the borer fauna of swamp, slump and cyclone-killed trees and drift timber to obtain evidence on the survival or destruction of boring insects by immersion in brackish and salt water.

The compilation of the food-plants of forest insects has been continued with the issue of the families *Platypodidæ* and *Scarabæidæ*.

Insect collections.—Small batches of forest insects have been identified and returned by the following specialists: *Endomychidæ*, *Erotylidæ* and *Lamellicornia* by Dr. G. Arrow; *Adephaga* and *Carabidæ* by Mr. H. E. Andrews; *Tenebrionidæ* by Mr. K. G. Blair; *Diptera* by Mr. E. Brunetti; *Cleridæ* by Mr. J. Corporaal; *Formicidæ* by Mr. St. J. Donisthrope; *Odonata* and *Pyralidæ* by Mr. T. B. Fletcher; *Odonata* by Major Fraser; *Bostrychidæ* by Mons. P. Lesne; *Curculionidæ* by Dr. G. A. K. Marshall; *Micro-lepidoptera* by Dr. E. Meyrick; *Asilidæ* by Miss G. Ricardo; *Termitophila* by Mr. Wasman; *Apidæ* by the Government Entomologist, Madras.

Some 350 species new to the Research Institute collection have been added during the period under review.

Staff.—Messrs. D. Atkinson and J. C. M. Gardner who have been selected for appointment to two of the posts of Divisional Forest Entomologist complete their training in forestry and entomology at the close of 1921. Mr. J. M. D. Mackenzie, I.F.S., will be appointed as Divisional Forest Entomologist to investigate the beehole borer in Burma.

VETERINARY SCIENCE

BY

W. A. POOL, M.R.C.V.S.,

Officiating Director and First Bacteriologist, Muktesar.

Rinderpest.—The following experimental work was taken in hand :—

(1) The preparation of anti-rinderpest serum using animals of moderate susceptibility as virus producers.

(2) A further investigation into the duration of the immunity conferred by serum alone.

(3) An investigation into the nature of the immunity conferred by very large doses of serum when given simultaneously with a dose of virulent blood.

(4) The elaboration of a special apparatus for bleeding the virus producers and injecting the serum producers for use in large scale rinderpest serum production. Bulletins on these subjects are in course of preparation and will shortly be sent for publication.

Equine Contagious Abortion.—Experiments were carried out with a bacillus obtained from aborted fœtuses at the Government Cattle Farm, Hissar, which proved to be the *B. abortivo equinus.*

An account of these experiments will be published shortly.

Reports from Veterinary Colleges and Provincial Laboratories.—With the exception of those detailed below no scientific work of any particular interest was carried out by the Veterinary Colleges and the Provincial Superintendents of the Civil Veterinary Department except that the Superintendent, Civil Veterinary Department, Madras, states that "a special work is being conducted on the causation of lymphangitis in cattle as occurring in Madras at the Madras Veterinary College, but is not yet completed."

The Director of Agriculture, Punjab, gives the following short summary of the Scientific Work carried out by the local Veterinary Officers in the Punjab during the year 1920-21 :—

I. *Camel Specialist, Sohawa.*

"The treatment of surra in camels by intravenous injections of Tartar Emetic. As the result of these experiments Tartar-Emetic gives promise of being efficacious in the treatment of this disease. Several months after

these camels had been returned to duty Sir John Moore informed me he had inspected them and found them in excellent condition. These camels are now working in Waziristan.

2. Experiments in connection with camel mange and its treatment. Of different dressings tried, the best results have been obtained by Taramira oil.

3. Surra Transmission Experiments.

4. Experiments were carried out in connection with spirochætosis of fowls, from which it was shown that 95 per cent. of infected fowls can be cured by intravenous injections of Soamin.

5. Observations were made with reference to Hypoderma larvæ of goats and the best means to be adopted to reduce the loss caused by these larvæ were studied, the life history of the fly was also studied.

II. *Principal, Veterinary College, Lahore.*

1. Work at Antirabic inoculation in dogs by Mr. W. Taylor.

2. Investigations in a curious Poultry disease by Messrs. Taylor and Sewell.

III. *Government Cattle Farm, Hissar.*

Feeding experiments on cattle with cake and leaves of certain trees."

MEDICAL RESEARCH

BY

The Hon'ble Major-General Sir William Rice Edwards, K.C.I.E., C.B., C.M.G., M.D., F.R.C.S.E., K.H.P., I.M.S.,

Director-General, Indian Medical Service.

The following is an extract from the Annual Report of the Scientific Advisory Board of the Indian Research Fund Association for 1920-21 :—

Relapsing fever.—An enquiry into relapsing fever with particular reference to the mode of transmission in India was sanctioned in November 1920 but started in February 1921. It is being carried out by Major F. W. Cragg, I.M.S., of the Central Research Institute in the United Provinces, Central Provinces and Punjab.

Plague and Rat-fleas.—The Governing Body of the Indian Research Fund Association have sanctioned an investigation on rat-fleas in India by Major Cragg.

Leprosy.—1. *Dr. E. Muir* is engaged at the Calcutta School of Tropical Medicine in carrying out an inquiry into leprosy with an allotment of Rs. 20,000 a year of which Rs. 10,000 will be donated by the Calcutta School of Tropical Medicine. The inquiry commenced on the 1st November 1920.

2. *Dr. Sudhamoy Ghosh* continued his researches under the supervision of Lieut.-Colonel J. W. D. Megaw, I.M.S., on special duty, at the School of Tropical Medicine and Hygiene. He is especially studying the chemistry of chaulmoogra oil with a view to obtaining substances of therapeutic value in the treatment of leprosy.

Grant to Rev. Dr. Frank Oldrieve for—

(1) Training of medical subordinates in modern methods of leprosy treatment, and

(2) Trial of the latest treatments of leprosy.

A grant of Rs. 21,650 was made to the Mission for Lepers in India in 1918 in connection with the experiments relating to the medical treatment of leprosy.

Inquiry on neem or margosa oil and its derivatives.—This inquiry has been extended for one year from 1st March 1921 and Dr. Chatterjee is concentrating his attention on the treatment of malignant growths with neem or margosa oil and its derivatives.

Influenza.—1. *Epidemiological inquiry.* This inquiry was under Major H. H. King, I.M.S., and terminated on the 7th April 1921 on his departure on leave. He has drawn up an important report for All-India dealing with the questionnaire regarding the epidemiology, etc., of influenza issued by the

office d'Hygiene International, Paris. This has been received and sent to Paris. (Since published in the Bulletin de L'office D'Hygiene Institute, August 1921.)

2. *Bacteriological inquiry.* Captain R. H. Malone, I.M.S., concluded his influenza bacteriological inquiry on the 4th December 1920.

Pneumonia.—On the conclusion of the influenza bacteriological inquiry Captain Malone was employed on the Pneumonia inquiry. This inquiry was sanctioned for one year in the first instance with effect from 5th December 1920.

Deficiency Diseases.—Colonel McCarrison started this research on the 29th January 1921 in England. This investigation is being carried out at Oxford in the Laboratory of Professor Sherrington, P. R. S.

Indian Mosquitoes.—The Indian Research Fund Association have provided funds for this inquiry to be continued for three years by Capt. P. J. Barraud. It commenced on the 26th February 1921.

This inquiry is on the culicidæ of India and has a direct and important bearing on the problem of prevention of yellow fever.

Kala-azar.—1. *Mrs. H. A. Adie* concluded this inquiry on the 25th January 1921. She published* a paper on "Developmental forms succeeding the multiplicative stage in *C. lectularius* fed on Kala-azar spleen uice". The Indian Research Fund Association has sanctioned the further continuance of the inquiry under her at Shillong for one year and she commenced fresh researches on possible insect vectors of this disease from 26th April 1921. She will work at the Pasteur Institute, Shillong, under the direction of Major F. P. Mackie, I.M.S.. She has already obtained some very suggestive and interesting results.

2. The Governing Body have sanctioned a further extension of Dr. U. N. Brahmachari's enquiry for one year. He has been provided with a chemical and physiological assistant and he will continue his researches on the organic preparations of antimony.

3. *Mr. P. R. Awati,* Medical Entomologist, commenced his insect survey in connection with Kala-azar in Assam in May 1920. He continued his work during the year. He is one of the team of workers engaged in Assam in the research on the etiology of Kala-azar.

Hookworm disease.—The inquiry into this disease was continued by Dr. K. S. Mhaskar during the year. In conjunction with Father Caius he published six more papers on the chemical composition of various drugs used in the treatment of the disease. Under instructions from the Working Committee in Madras, formed at the end of the year under review, he has been directed to proceed with new lines of research.

Ground nuts and sterilisation of water supplied by chlorogens.—Dr. Mackenzie Wallis is continuing his research in England. A report of his investigation has been called for.

* Indian Journal of Medical Research, Vol. 8, No. 7, October 1921.

Schistosomiasis cercariae of Egypt.—Major Sewell has written a very important monograph entitled *Cercariae Indicae* being the result of his investigations on this subject in India. This paper is being published by the Indian Research Fund Association as a Monograph in a special number of their Journal.

Entomology and Protozoology.—In the month of January 1921, Major W. S. Patton, I.M.S., conducted his inquiries on entomology and protozoology for which a grant of Rs. 5,000 was sanctioned by the Governing Body of the Indian Research Fund Association.

Immunity with special reference to antivenin.—The Governing Body of the Indian Research Fund Association have sanctioned for a period of one year a research on immunology with special reference to antivenin by the Rev. Father J. F. Caius of Trichinopoly. One of the main objects of this inquiry will be the concentration of the antivenin serum now prepared at Kasauli.

Malaria and its treatment by Cinchona derivatives.—This inquiry will be carried out by Major J. A. Sinton, V.C., I.M.S., under the direction of the officer in charge of the Malarial Bureau of the Central Research Institute of Kasauli. The inquiry will be carried on over a period of five years.

Grants to the schools of Tropical medicine and Hygiene at Bombay and Calcutta.—The Indian Research Fund Association have sanctioned :—

(*a*) The sum of Rupees one lakh towards the extension of the buildings of the Calcutta School of Tropical Medicine to provide for teaching and research in hygiene and (*b*) a non-recurring grant of 1½ lakhs towards the establishment of the School of Tropical Medicine at Bombay.

INDEX.

A

	PAGE
Afforestation experiments at Zabarkhet	39
Air, study of the upper	10
Anthracnose of Chilli, result of, work on	33
Anthropology, physical	46
Anti-rabic inoculation in dogs, work on	54
Antivenin serum preparation	57
Artemisia maritima, medicinal products of	7
Atmospheric refraction investigations	19

B

Bacterial rot of potatoes in Assam	36
Beans, investigation of the Hydrocyanic content of	4
Borer fauna of timbers, determination of	52
Boswellia serrata, separation and utilisation of resin from	6
Botanical survey in Burma	23
„ „ „ Eastern India	23
„ „ work, systematic	23
work in Northern India	23
„ „ Southern „	24
„ „ Western „	23

C

Camels, work on diseases of	53
Camphor and camphor oil, experiments on	6
„ experimental silviculture of	39
Catalogue of scientific periodicals, preparation of	1
Cellulose, fermentation of	7
Cereal diseases, study of	32
Charcoal Briquette investigations	43
Chir, experimental afforestation of	39
Chlorogens and water sterilisation	56
Choanephora of Chilli, results of, work on	33
Cinchona cultivation in Burma	24
„ derivatives in Malaria, inquiry into use of	57
Control of " mosquito blight ", investigation into	50
Cotton, botanical investigations of	26
„ investigations in Madras	26
„ selection and improvement of	26
Crustacea, collections of	46

D

	PAGE
Decomposition of green manure, investigation of	2, 37
Deficiency disease, investigation into	56
Dendrocalamus strictus as a fodder plant	28
Diseases of cereal crops, work on the	32

E

Eleusine coracana cultivation in Mysore	28
Entomological work at Pusa	47
„ „ of the Indian Tea Association	50
„ „ in Native States	49
„ „ „ the provinces	47
Entomology and protozoology, inquiry on	57
Equine contagious abortion	53
Ethnological collections, additions to the	46

F

Fibre investigations	27
Flax, experiments at Cawnpore with	27
„ „ in the United Provinces	27
Flora of Madras	24
„ Upper Gangetic Plain	23
Forage plants investigations	28
Forecasting, daily and seasonal weather	10
Forest insects, collection and identification of	52
Fruit, papers on	27

G

Geological economic enquiries	13
„ surveys	13
Geology, stratigraphical work	13
Grazing experiments in the Deccan	28
Green fly, breeding records of	50
Green manuring on sandy soils, value of	3
Ground phosphate and green manure	3
Guava, studies in the root system of the	27

H

Helminthosporium on cereal and sugarcane, study of	32
Hill-stream fishes, collection of	46
Hookworm disease investigations	56
Hypoderma larvæ of goats, study of	54

I

	PAGE
Immunological investigations	57
Indian Mosquitoes, inquiry into	56
Indigo, bacteriological investigation of	36
,, colour, test of	36
,, conditions affecting quality of	4
,, deterioration of seeds of	5, 27
,, effect of oversteeping on yield of indigotin from	5
,, manurial trials of	4
Influenza, investigations	55
Insect pests on various crops, work on, at Pusa	47

J

Jute experiments in Bengal	27
,, plant, research on the composition of the	4

K

Kala-azar, work on	56

L

Leprosy investigations	55
Levelling work of the Trigonometrical survey	16
Libraries in India, provision of scientific	1
Longitude observation by wireless telegraphy	18

M

Magnetic elements at observatories	11
,, observations, reduction to epoch of	11
,, storm in May 1921, description of the	12
,, survey work	11
Mahua flower, biochemical work on the	7
Malaria, inquiry into the use of Cinchona derivatives in	57
Mango cultivation in Bombay	27
Manures and manuring	2
,, availability of ground phosphate	2
,, nitrogenous, availability of, in Mysore	3
Margosa oil in the treatment of malignant growths	55
Marine Biological Station at Port Blair, proposal for a	1
Millets, cultivation of	28

PAGE

Minerals, economic enquiries on 13
Monsoon rainfall of the Peninsula, correlation co-efficient for the 10
Mosquito investigations 56
Mycological work in the provinces 33
,, ,, on Tea 35

N

Nitrogenous manures on Red Mysore soil 3
Nitrogen, seasonal variation of soil 2
Northern India, botanical work concerning 23

O

Oil from the leaves of *Skicmmia laureola* 6
,, ,, seeds of *Garcinia Cambogia* 6
,, ,, ,, ,, *Morella* 6
,, ,, ,, *Mimusops Elengi* 6
,, ,, *Zanthoxylum* seeds, examination of 6
,, seeds castor, oils content in 3
,, ,, coconut, inquiry on 3
,, ,, work on 3
Oleo-resin industry 43
Opium, chemical work on alkaloids of 3
,, factors influencing morphine content of latex 3
,, process for determination of morphine 3
,, production of 27
Orange, studies in the root system of the 27

P

Palmyra palms, bud rot of 33
Paper in India, perishing of 1
,, pulp industry, observation and encouragement of the 42
Pest of tea, breeding records of 50
Plague work 55
Pneumonia, bacteriological work on 56
Poultry disease, investigation of 54
Proceedings of the fortieth meeting of the Board 1
Protozoological work 57

R

Rat-fleas, investigation on 55
Relapsing fever investigations 55

PAGE

Resin industry 43
Rice, assimilation of nutrients by—in Bombay 3
„ breeding and transplanting of 26
„ experiments in parboiling of 3
„ papers on swamp 26
Rices, classification of the Central Provinces wild 27
Rinderpest investigations 53
Rosa grass oil, industry of 43

S

Sal, oecology and soil æration of 29
„ regeneration system of 29
„ root disease of 30
„ work on the insect pests of 51
Schistosomiasis investigations 57
Shorea robusta, experimental work on natural reproduction of 29
Silvicultural systems, development in 40
Silviculture, statistical work on 38
Soil acidity in Assam 2
„ biological investigations 36
„ chemical survey of 2
„ gases, work on 2
„ investigations at Pusa 2
„ moisture, investigation of the movement of 2
„ seasonal variation of organic Nitrogen in 2
„ surveys in India 2
Solar Physics work at Kodaikanal 8
„ prominences, study of 9
Spectroscopic research 8
Spirochætosis of fowls, experiments carried out in the treatment of . . . 54
Storms, analysis of cold weather 10
Stratigraphical investigations 13
Sugarcane, botanical papers on 27
„ experiment on windrowing of 3
„ „ with imported varieties of 27
„ importance of habit in 27
Sun-arc displacements studies 8

T

Tamarix, systematic study of 30
Tanstuffs in the Sunderbans, investigations of 43
Tartaric acid from tamarinds, extraction of 7
Tea, changes during withering of leaf of 4
„ chemical investigations in 4
„ diseases of 35
Teak, oecology of 30
„ work on the insect pests of 52

PAGE

Tidal operations 15
„ registration work 15
Timber, antiseptic treatment of 42
„ seasoning powers and physical and mechanical properties of . . . 42
„ markets and new uses of 42
Triangulation networks adjustment 20
Trigonometrical survey work 16
Turpentine, chemical research into 6

V

Venus, spectra of the planet 8
Veterinary Colleges work 53

W

Water sterilisation 10
Weather forecasting 10
Western India, botanical work concerning 23
Wet bulb temperatures, application of, in thermodynamical problems . . . 10
Wild rices, classification of 27
Wireless telegraphy in Longitude observations 18
Wood distillation, researches on 7

Z

Zoological collections, additions to the Zoological survey 46
Zoological survey tours 45

Departmental Publications.

I.—Meteorological Department—

Government of India Office.

(1) The Indian Daily Weather Report and Chart.
(2) The Weekly Rainfall Summary.
(3) The Monthly Weather Review.
(4) The Annual Summary.
(5) The Rainfall of India.
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Bengal Office.

(1) Bengal Daily Weather Report and Chart.
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(2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

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(1) Bombay Daily Weather Report and Chart.
(2) Monthly Rainfall Tables (*Madras Gazette*).

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(2) Annual Summary.
(3) Monthly Rainfall Tables (*United Provinces Gazette*).

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II.—Geological Survey.

The publications of the Department include—

Palæontologia Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

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Manual, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta.

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(2) Records of the Botanical Survey, Vols. I—IX
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FOR THE YEAR

1921-22

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CONTENTS

		Page.
I.—Proceedings of the Board		1
I.—Annual Report—		
APPLIED CHEMISTRY—		
I.—*Agricultural*	W. H. Harison, D.Sc.	3
II.—*Forest*	J. L. Simonsen, Ph.D.	6
ASTRONOMY	G. T. Walker, C.S.I., M.A., Sc.D., F.R.S.	8
METEOROLOGY		
TERRESTRIAL MAGNETISM		
GEOLOGY	L. L. Fermor, O.B.E., A.R.S.M., D.Sc. (London), F.G.S., F.A.S.B.	14
GEODESY	Lieutenant-Colonel H. McC. Cowie, R.E.	16
BOTANY—		
I.—*Botanical Survey*	Lieutenant-Colonel A. T. Gage, I.M.S.	29
II.—*Economic Botany*—		
I.—*Agricultural*	A. Howard, C.I.E., M.A., A.R.C.S., F.L.S.	33
II.—*Forest*	R. S. Hole, C.I.E., F.C.H.	38
III.—*Mycology*	W. McRae, M.A., B.Sc., F.L.S.	43
AGRICULTURAL BACTERIOLOGY	C. M. Hutchinson, B.A., C.I.E.	48
FORESTRY—		
I.—*Silviculture*	Captain H. Trotter, M.C.	49
II.—*Economic Forest Products*	W. A. Robertson, I.F.S.	53
ZOOLOGY—		
I.—*General Zoology and Physical Anthropology*	N. Annandale, D.Sc., F.A.S.B.	56
II.—*Economic Entomology*—		
I.—*Agricultural*	T. B. Fletcher, R.N., F.L.S., F.E.S., F.Z.S.	58
II.—*Forest*	N. C. Chatterjee, B.Sc., F.E.S.	64
VETERINARY SCIENCE	J. T. Edwards, B.Sc., M.R.C.V.S.	68
MEDICAL RESEARCH	The Hon'ble Major-General Sir W. R. Edwards, K.C.I.E., C.B., C.M.G., K.H.P., M.D., I.M.S., F.R.C.S.E.	71

Annual Report of the Board of Scientific Advice for India, 1921-22.

SUMMARY OF PROCEEDINGS.

Forty-first meeting held at Simla on the 22nd May 1922.

The Board considered and accepted the programmes of the various Scientific Departments for 1922-23.

The President announced that the Government of India had selected Mr. J. T. Edwards, B.Sc., M.R.C.V.S., Director, Imperial Bacteriological Laboratory, Muktesar, as a member of the Board in place of Lieutenant-Colonel G. K. Walker, Principal, Veterinary College, Lahore, who had proceeded on leave.

It was resolved to approve the proposal of the President that Mr. J. T. Edwards, B.Sc., M.R.C.V.S., be appointed Chairman of Sub-Committee E. (Veterinary subject) in place of Lieutenant-Colonel G. K. Walker.

An endorsement from the Government of India regarding the nomination of Mr. J. A. Chapman as a member of the Board and of the Sub-Committee on the perishing of paper was read and recorded.

As regards the Catalogue of Scientific Periodicals in places in India outside Calcutta it was decided to elicit from the Education Department information as to what stage the publication had reached and to ask that the Library Sub-Committee submit a list of Scientific Periodicals suitable for Libraries in India.

The interim report by the Libraries Sub-Committee on the perishing of paper was read and recorded.

The report of the Sub-Committee appointed at the 40th meeting to consider the proposed establishment of a Marine Biological Station in the Andaman Islands was next read and considered.

The Board approved the report and recommended that its forwardal to the Education Department of the Government of India for acceptance.

APPLIED CHEMISTRY

PART I.—AGRICULTURAL CHEMISTRY

BY

W. H. HARISON, D.Sc.

Imperial Agricultural Chemist.

SOILS

Soil Surveys.—In Madras, the soil survey of the Periyar Delta has been completed and a general deficiency in P_2O_5 and lime is reported.

Somers-Taylor has extended his previous work by including the soils of the South Ganges diara which, unlike the soils further south, show no deficiency in either P_2O_5 or Nitrogen.

The soil survey of the Tea districts of North-east India has been continued by Carpenter who has published a note dealing with a peculiar class of soil, very well suited for tea, and found particularly in the Bengal Dooars.

Soil Nitrogen.—This important subject is at present receiving a considerable amount of attention. Somers-Taylor has made observations on the variations in Total Nitrogen in Bihar Soils, and Meggitt, in Assam concludes that a serious loss of Nitrogen may take place during the rainy season if the land is fallowed, and kept clean and cultivated. Vegetation in these conditions exerts a protective influence.

Clark has studied, and is publishing his observations on, the fluctuations in the amount of Nitrate in uncropped cultivated soils of the Gangetic plain and Harrison is investigating the movement of the Nitrate in soils to a depth of nine feet in connection with their availability for crop production.

Saline Soils.—The reclamation of Bara and Saline soils in the Montgomery District has received attention from Lander who reports hopeful results from treating the former with gypsum and castor cake followed by suitable cropping.

Miscellaneous.—Mukerji has extended his observations to the relative formation of CO_2 in irrigated and unirrigated grassed plots and has confirmed his previous conclusions. Sen is endeavouring to correlate the unevenness of the crop in certain fields at Pusa with variations in sub-soil characteristics.

Atkins has determined the Hydrogen-Ion concentration of certain Indian Soils and finds variations of PH 8·7 in the Calcareous silts of Bihar to PH 5·3 for a black peaty soil from Shillong.

MANURES AND MANURING.

Phosphatic Manures.—A study of the availability of different phosphates in Mysore Soils has been made by Narasinha Iyengar, and Carberry reports striking results from applications of Bone meal and lime to the red laterite soils of Eastern Bengal.

Norris in Madras has found on the Manganallur Farm that mineral phosphates composted with green manures have not proved successful; better results being obtained by direct application of the phosphate to the soil in conjunction with green manuring. Plymen is also studying the effect of fermenting green manure on P_2O_5 solubility.

Organic Manures.—The nitrification of oil cakes in soils is under observation by Plymen in the Central Provinces and Norris in South Malabar. The former finds that *Bassia latefolia* cake is very resistant. Comparative test with oil cakes against sodium nitrate and ammonium sulphate have been carried out by Narasinha Iyengar.

Fowler is studying the chemical changes producing loss of nitrogen in manure heaps, whilst the production of artificial Farmyard manure is being investigated in Madras and the Central Provinces.

Manuring of Special Crops.—Carpenter has attempted to correlate the effect of various manures on the composition of the Tea leaf, and finds that potash manuring gives immunity to mosquito blight in sandy soils but in clay soils it is unlikely that similar results will be obtained.

Narasinha Iyengar, from field experiments in Mysore, reports the Nitrogen and P_2O_5 are most wanted by sugar cane while with areca palms oil cakes are more effective than ammonium sulphate.

Meggitt and Somers-Taylor have studied the changes taking place in sugar cane during the ripening stage and Norris is endeavouring to devise a rapid refractometric method for determining the ripeness of cane in the field.

CROPS.

Sugar Cane.—A large scale trial of Coimbatore seedling canes has been carried out by Clarke under U. P. conditions with very satisfactory results and one seedling, CO. 214, is reported to be of considerable merit.

Rice.—Sahasrabuddhe has completed a study of the composition of the crop at various stages of growth and Charlton has investigated methods of mitigating the nuisance caused by par-boiling paddy.

Cocoanut and Date Palms.—The tapping of coconut palms and the production of improved jaggery or gul has been independently investigated

by Norris in South Malabar and Sahasrabuddhe in Bombay, while Carberry in Eastern Bengal has evolved a more economical type of furnace for the production of date-palm sugar.

Tea.—Carpenter from observations made on the tannin content of the leaf concludes that this increases at the time when poor quality teas are being made. He has also investigated the effect of the manufacturing process on the tannin content of the finished product.

Opium.—In continuation of his previous work, Annett has devised new improved methods for the determinations of Narcotine, Papaverine, Codein, Morphia and Meconic Acid. He finds that the alkaloids in opium are present as meconates and that the darkening of the poppy latex is due to oxidizing enzymes. Observations upon the oil content of poppy seeds are ready for publication.

ANIMAL NUTRITION.

With the appointment of a Physiological Chemist to the Pusa staff in October 1921 work in connection with the nutrition of Indian cattle has been started.

The results hitherto obtained are necessary only of a preliminarily character but they distinctly point to the fact that food values of Indian fodder fed to Indian cattle will be very different to similar values obtained in other countries.

It is also of interest to note Lander in the Punjab and Narasinha Iyengar in Mysore have feeding experiments under observation.

APPLIED CHEMISTRY

PART II.—FOREST CHEMISTRY

BY

J. L. SIMONSEN.

Forest Chemist, Forest Research Institute, Dehra Dun.

Essential Oils—(1) Carum Copticum.—Lakhani, Sudborough and Watson (Journ. Ind. Inst. of Science, Vol. IV, p. 59) have published a long and detailed account of their work in the manufacture of thymol from Ajowan seed (*Carum Copticum*).

(2) **Lantana Camara.**—The oil from the shrub *Lantana Camara* has been investigated by Moudgill and Vridhachalam (Perf. Ess. Oil Rec. 1922, Vol. 13, p. 173). The oil would not appear to have any commercial value.

(3) **Pinus excelsa.**—The turpentine from the oleo-resin of *Pinus excelsa* has been examined at Dehra Dun. It has been found to contain *d-l*-pinene, *d*-terpineol, a sesquiterpene and *n*-undecane. The presence of the last named hydrocarbon, belonging to the paraffin series, is interesting.

(4) **Abies Pindrow, Spach.**—The needle oil from *Abies Pindrow, Spach* has been examined and the results of the investigation published. (Ind. For. Rec. 1922. VIII. 363).

(5) **Blumea Malcolmii.**—The essential oil from this grass has been found to consist almost entirely of *d*-carvotanacetone and *l*-tetrahydrocarvone (Journ. Chem. Soc. 1922. *121*. 877).

(6) **Andropogon Jwarancusa, Jones.**—The oil from the grass grown in Hazara has been shown to contain over 70% of *d*-piperitone and approximately 20 per cent. of a new bicyclic terpene which is at present under investigation. (Journ. Chem. Soc. 1921. *119*. 1644). An examination of the oil obtained from the grass grown in Sind has shown it to possess very different properties. Full details of this work will appear in a forthcoming paper in the Indian Forest Records.

(7) **Zanthoxylum alatum, Zanthoxylum budrunga, Zanthoxylum acanthopodium.**—The oils from the seeds of these three species of Zanthoxylum have been investigated and a paper on the subject is now in the press.

Fixed oils.—The oils from the seeds of *Chloroxylon Swietenia, Calophyllum Wightianum, Shorea robusta, Mimusops Elengi* and *Garcinia Cambogia,*

have been investigated at Dehra Dun and a paper embodying the results of the investigation is in the press.

A number of papers were read at the 9th meeting of the Indian Science Congress on fixed oils from the seeds of Indian Forest trees but mention may be deferred until the full papers were published.

Miscellaneous.—Fowler and Bannerjee (Journ. Ind. Inst. of Science, Vol. IV, p. 241) have made a preliminary study of the use of megasse as a source of paper pulp and power alcohol.

Majima (Berichte 1922, *55*, *B*. 191) in continuation of his valuable study of the chemistry of Japanese lac has also studied Burmese lac the so-called "Thitsi" gum from the stems of *Melanorrhea usitata*. Wall. The Japanese and Burmese lacs show marked chemical differences.

Nierenstein (Journ. Chem. Soc. 1922. *121*. 604) has published some further results of his experiments on the constitution of catechin.

ASTRONOMY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., Ph.D., F.R.S.,

Director-General of Observatories.

Solar Physics.—Researches in solar physics are carried on at Kodaikanal under the direction of Mr. J. Evershed, F.R.S.

Routine work.—Daily spectroheliographic records are obtained in calcium and in hydrogen light ; the routine work also includes visual examination of sunspots and faculæ, sunspot spectra, and bright lines or displaced lines in spots and in prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review" while for more technical purposes bulletins and memoirs of the Observatory are issued. Of the former 69 have appeared and of the latter 2 have been published.

Spectroscopic Research.—It was shown in Kodaikanal Observatory Bulletin No. 38 that lines which are unsymmetrical in width in the electric arc have abnormal displacements in the solar spectrum. These lines also undergo displacements under varying conditions of the electric arc which have been designated as the "pole effect." A new condition affecting their wave-length in the arc has now been discovered, namely, the nature of other substances in the arc simultaneous with the element whose spectrum is under investigation. It has been found that one of the unsymmetrically widened copper lines undergoes the following displacements according to the nature of substance introduced into the arc : with sodium +·050 A (*i.e.*, to the red), with calcium +·035 A, with iron +·016 A, with silver +·015 A, with aluminium +·014 A, with nickel +·005 ? A. The cause of the displacements of unsymmetrically widened lines was suggested in K. O. Bulletin No. 38 as due to differences in vapour density, although it was stated in K. O. Bulletin No. 40 that density of ions might have to be substituted for density of vapour. It now appears likely that differences of density of ions are the true cause of the displacements of unsymmetrically widened lines, for it can be shown that the displacement of these lines goes parallel with their displacement in an electrical field. It would appear that the displacements in the electric arc are caused by the electrical field due to neighbouring ions, and that in the Sun the density is sufficiently low for ions to be separated to distances at which their electrical field is small. These experiments are now being continued and extended for their complete elucidation and to test the above explanation of their cause.

Wave-lengths have been determined on the international scale of selected solar lines in two spectral regions, and including spectra of general sun-

light, the centre of the Sun's disc, and the equatorial and polar limbs. The results have been communicated to the International Astronomical Union. In this work some remarkable differences are found for certain lines in spectra photographed in 1914 and others obtained in 1921.

Two series of plates of the sodium lines D_1 and D_2 in Sun and arc have been obtained to determine the displacements of these lines in the Sun. The two series give slightly different results but agree in indicating a nearly zero pressure in the Sun's absorbing atmosphere. The Sun-arc shift when corrected for the higher pressure of the arc in air would appear to be very approximately in agreement with the shift predicted by Einstein.

A new autocollimating prism spectrograph was completed and brought into use in October 1921. This instrument has proved very efficient, and a fine series of Venus spectra were secured in November and December 1921 when the planet was a morning star approaching superior conjunction; and again in April and June 1922 as an evening star. Measures of the earlier series give mean wave-lengths differing only very slightly from those in direct sunlight; a result that is also favourable to Einstein interpretation of the shift of the solar lines.

With the same instrument a series of spectra of Sirius was obtained on the same scale as the Venus spectra. Comparing the Venus (solar) and Sirius spectra with this high dispersion has revealed the fact that the metallic lines in Sirius are very much wider and less dark than in the sun. The possible causes of this widening are discussed in a paper submitted to the Royal Astronomical Society in May.

METEOROLOGY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., PH.D., F.R.S.,

Director-General of Observatories.

Upper Air.—Observations with pilot balloons had to be much restricted in the year 1920-21 and at the beginning of the year this work was being done only at Bangalore (with the co-operation of the Government of Mysore), Agra, Simla and Lahore. Later in the year it was found possible to extend the work to a few other stations: Calcutta and Akyab were re-opened in May and August respectively, and two new stations Quetta and Peshawar were started, the former in June and the latter in September.

The Central Observatory at Agra, besides exercising a close supervision over the current work of these outstations, was busy clearing up the war-time arrears in the computations of the upper air data.

A complete analysis of cloud observations made from 1914 to 1919 and also of observations with kite and sounding balloons made up to the year 1918 were undertaken, and three papers giving the results of this work were compiled for publication in the India Meteorological Memoirs.

The paper "On exposures of thermometers in India" is in the Press and about to be published.

Prof. P. C. Mahalanobis of the Presidency College, Calcutta, spent some months in Simla on research work and wrote two papers, the first on the seat of activity in the upper air and the second on the effect of the errors of observations on upper air relationships. These will be shortly published.

Daily and seasonal forecasting.—Shortness of staff prevented any of the gazetted officers from carrying on the preparation of type maps for daily forecasting.

Statistical work for investigating the relation of pressure at centres of action with the monsoon rainfall of the Peninsula was undertaken and a formula was obtained which would enable the department to make a forecast in February with a correlation coefficient nearly as high as that obtained with the old formula for the June forecast. For the forecast in June itself a formula was obtained which gave a correlation coefficient of ·8. The investigation was extended to the monsoon rainfall of north-west India also, but the results have not so far been very successful.

The normals of all the elements recorded at our observatories and of the rainfall at all the authorised rainguage stations were revised and brought up to the year 1920 and are being arranged for publication.

A memoir on the local distribution of monsoon rainfall has been published.

TERRESTRIAL MAGNETISM

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., PH.D., F.R.S.,

Director-General of Observatories.

Magnetic Observatories—Bombay (Alibag).—For a description of the instruments and of the routine work reference should be made to the Annual Report of the Director of the Observatory. The quinquennial volume giving the magnetical, meteorological and seismological observations made at Bombay and Alibag Observatories during 1911-15 has been published during the year. The volume for 1916-20 is in the Press. A selection from the disturbed magnetic records obtained at the Alibag Observatory during 1906 to 1915 has been printed and will shortly be issued by the Bombay Observatory with a brief discussion.

Magnetic Survey.—No. 18 Party (Magnetic) Survey of India.—The declination, horizontal force and vertical force magnetographs continued in operation throughout the year at the Dehra Dun and Toungoo Observatories and daily absolute magnetic observations were taken regularly by the observers in charge. The observatories were visited during the field season and observations, consisting of declination, dip and horizontal force, were taken for the comparison of instruments.

The Kodaikanal and Alibag Observatories, under the control of the Meteorological Department, were also visited by the officer in charge of the magnetic survey for the same purpose.

Observations at Repeat Stations.—Magnetic observations were taken this field season at the six repeat stations—Quetta, Karachi, Bina, Dibrugarh, Barrackpore and Waltair—these stations are visited annually to supplement the 5-yearly observations at all repeat stations, in order to obtain accurate determinations of the annual changes in the magnetic elements, as explained in last year's report.

Publication of the results of the magnetic survey.—The final reduction of the magnetic observations at the field and repeat stations in India, Burma and Ceylon, to the epochs 1909-0 and 1920-0, have been completed. The results, which are now in the press, will be published as soon as the maps, diagrams, etc., have been printed.

Special observations.—In response to a request by Dr. L. A. Bauer, Director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, special magnetic observations will be taken during the Total Solar Eclipse of September 21, 1922 at Alibag, Kodaikanal, Dehra Dun and Toungoo for investigating the eclipse effects on the Earth's magnetism.

GEOLOGY

BY

L. L. FERMOR, O.B.E., A.R.S.M., D.Sc. (LONDON), F.G.S., F.A.S.B., M.INST.M.M.

Offg. Director, Geological Survey of India.

Mineralogy.—A brief examination was made of the occurrences of solid bitumen or mineral pitch found in cavities in basalt west of Seori Fort, Bombay. It is suggested that the origin of this bitumen is due to the distillation of the carbonaceous matter of the organisms in intertrappean beds invaded by a sill of intrusive dolerite.

Palæontology.—Descriptive work has been continued on the Tertiary fossils of Burma and North-Western India, upon the intertrappean fossils of Peninsular India, upon Devonian fossils from Chitral and the Pamirs, and Anthracolithic and Triassic fossils from Yunnan. Amongst vertebrates, studies have also been made of Anthracotheridæ from Baluchistan and Dinosaurian remains from Jubbulpore. Short papers have been completed on various Gondwana plants.

Stratigraphy.—An interesting discovery was made by Mr. Sinor, State Geologist to the Rewah Durbar, of marine fossils of Gondwana age at Umaria in Central India. Two species have been recognised belonging to the genera *Productus* and *Spiriferina*. This discovery indicates the extension in Talchir times of the northern Carboniferous sea as far south as Central India, giving a northern limit to the edge of Gondwanaland in this neighbourhood in Talchir times.

Geological Surveys.—A survey was made of a considerable tract on the southern edge of the Khasi Hills, connecting up previous work to the east and to the west. The survey of the ferriferous belt of Singhbhum was continued, and also the general systematic survey of the Central Provinces. A portion of the Aravalli range in Jodhpur State (Rajputana) was surveyed and a detailed examination of Salsette Island (Bombay) was undertaken. In Burma, the systematic survey of Mergui was continued, and also the mapping of the Tertiary formations in the Pakokku and Lower Chindwin districts. In addition, the recently discovered occurrences of oil shales in the Amherst district adjoining the Siamese frontier were examined, and geological observations made that permit of a comparison between the geology of Amherst and that of the Southern Shan States. The railway survey carried out from Ledo in Assam through the Hukong valley to Mogaung in the Myitkyina district of Upper Burma afforded an opportunity for the

geological examination of a tract not previously visited. During the hot weather a beginning was made with the systematic geological examination of Chitral State, and the results obtained during the first-season's work confirm and amplify the results previously obtained in a traverse by Sir Henry Hayden. A beginning was also made with the systematic survey of the Poonch Ilaqa, the most interesting result obtained being the discovery of two or more bands of bituminous limestone carrying nummulites intercalated in steeply dipping Murree beds. An officer was deputed to accompany the Mount Everest Reconnaissance Expedition, this resulting in the preparation of a geological map of over 8,000 square miles of territory, comprising the western portion of the Tibetan section of the Arun drainage area, and the region drained by the headwaters of the Bhotia Kosi and its tributaries. The tract mapped lies to the west of that mapped by Sir Henry Hayden at the time of the Tibet Expedition in 1903-4.

Economic Enquiries.—Investigations were made regarding the following minerals: amber in Upper Burma; orpiment in Chitral; bauxite and building stones in Salsette Island, Bombay; coal in the Talcher coalfield; graphite and mica in the Ruby Mines district of Burma; iron-ores in Singhbhum, Orissa and Chitral; lead-ores on the Burma-China frontier; oil shales in Amherst district, Burma.

Amongst engineering questions the sites for a tunnel of the Sutlej River hydro-electric project were examined, and also the sites of the Anu Khad hydro-electric project. Examinations concerning water-supplies were made at Quetta, Chittagong, Amraoti, Dhanbad, Salsette Island and Jodhpur. The superintendence of the boring for coal below the Deccan Trap at Bhusawal was continued, and an inspection of the manganese mines of the Central Provinces was undertaken in order to advise the Local Government of the extent to which the concessionaires were complying with the general terms of their leases, and with a view to suggesting directions in which improvements in methods of work could be effected.

GEODESY

A RETROSPECT

BY

LIEUT.-COL. H. McC. COWIE, R.E.,
Offg. Superintendent of the Trigonometrical Survey.

Owing to the exigencies of war, geodetic operations in India have been for many years in abeyance. The absence of experienced officers and the pre-occupation of the Survey of India Department generally with matters of greater present importance and urgency precluded the continuance of geodetic research. Amongst the investigations which had to be suspended for the time were those concerned with the interpretation of gravitational anomalies and the bearing of such interpretation on current theories of isostasy and the evolution of the structure of the Earth's crust. These investigations, which had reached a most interesting stage, were being followed somewhat closely in Europe and America. Other matters which had necessarily to await more favourable times included the inception of wireless longitude determinations, the measurement of essential base-lines and the adjustment of extensive triangulation lying outside the older and already adjusted geodetic framework of India, the determination of the relation between the original 10-foot Indian Standard of length and the modern metric standards acquired shortly before the outbreak of war, and the examination of triangulated heights in India and Burma with reference to the spirit-levelling.

Such were amongst the future activities contemplated by the programme interrupted at the end of 1914. It is hoped that the long period of enforced quiescence will shortly come to an end and, so, the present is, perhaps, not an inappropriate time for glancing at the past and taking stock of the present geodetic situation in India.

The Indian Triangulation.—Commenced in 1802 under the direction of Colonel Lambton, the general framework of triangulation, elaborated by Sir George Everest had, about 1880, reached the confines of what were then the attainable regions of India and, for a time, geodetic operations were suspended. The establishment, for the next few years, was employed on special secondary triangulation along the coasts of India to serve the purposes of the Marine Survey. At the end of 1888, geodetic triangulation was resumed and continued steadily until the season of 1913-14. By that year, extensions had been carried from Everest's framework eastwards to the boundaries of Siam

and Yunnan, westwards to Persia and northwards to effect a junction with Russian triangulation in the Pamirs. In 1907, the programme of trigonometrical operations was widened to include secondary triangulation supplementary to the principal framework and, by 1914, a definite beginning had been made to a regularly co-ordinated system of secondary triangulation.

At different times the principal triangulation of India has been criticised as being too precise. These criticisms, however, were generally based on an imperfect appreciation of the situation in India. The criteria by which the triangulation was judged were derived from European experience; the enormous area over which the triangulation would extend was but dimly realised and, perhaps more important still, the difficulties of making frequent base measurements in country where communications were few and bad, where little was procurable locally and most ordinary necessaries had to be transported over great distances, were not understood; neither was the fact appreciated that if the accumulation of inconveniently large errors in outlying parts of the triangulation was to be avoided, without the checks afforded by frequent base-lines, the degree of precision of the work would have to be higher than that deemed sufficient for the much smaller networks of Europe. The precision of the Indian triangulation is by no means unduly high. It ranks equally with the best of the older operations in Europe but by reason of the greater part of the work having been done before the construction of instruments, more especially of the dividing engine, had reached its present high quality, its average figure of merit is less than that of good modern triangulation.

At the end of the 19th century it was the precision of the Indian triangulation that was under criticism. To-day it is its sufficiency, in point of amount, for the future needs of India. Every year sees a certain number of the old stations of the principal triangulation disappear and unless considerable sums are spent on protective measures, this must occur. In that they are accurately fixed points, valuable as controls to the topographical surveyor, their loss must be viewed with concern unless there exists some system of secondary triangulation offering a sufficient number of points of adequate precision to render the disappearance of a principal station of small account. There has thus arisen the question of how much supplementary or secondary triangulation, properly co-ordinated with the principal framework, there is in India to provide for the needs of the future. Up to the beginning of the 20th century, it may be said generally, there was no such supplementary triangulation. Up till then there was no regular programme of such work and no definite agency to carry it out. As occasion arose, necessary triangulation was executed by either a topographical or a trigonometrical party as circumstances dictated. The marks were rarely permanent and it is probable much good work has been lost. In 1908, however, a commencement was made to a definite, enduring framework of secondary triangulation and by 1917, nearly 2,000 miles of secondary triangulation had been completed. At this point, operations were discontinued and up to date, conditions have remained so far abnormal that it has not been possible to resume them. Relae

tively to the areas to be provided for, only a very small amount of secondary work has been carried out and the Indian triangulation scheme is still far from complete. It may be pointed out that the trigonometrical survey of a country is not complete until a framework of secondary triangulation has been constructed, breaking down the large figures of the principal work to such extent as will economically suit the needs of the topographical surveyor. In India very little has been done towards this end and the average size of the principal figures is still very large. The average sized figure—

in	the United Provinces	is about	300	miles	×	70	miles
„	„ Northern Punjab	„ „	200	„	×	150	„
„	„ Southern „	„ „	250	„	×	150	„
„	„ Bengal	„ „	200	„	×	100	„
„	„ Central India	„ „	300	„	×	130	„
„	„ Burma	„ „	200	„	×	120	„

Over these there is nothing of the nature of the permanent supplementary triangulation existing in other countries. In Germany the largest principal figures are about 190 miles × 125 miles. In France and Spain the average size is about 120 miles × 120 miles. In all these countries the principal figures have been completely filled in with permanent supplementary frameworks. In Italy, Switzerland, Greece, and Japan there is a principal network covering the whole country with points about 35 miles apart. In Belgium and Holland there is a similar network with points 25 miles apart.

It is not claimed that the Indian principal and secondary triangulation network should be as dense as it is in Europe but it is affirmed that by reason of the disappearance of much of the old work and the failure, for want of means, to supplement the principal triangulation by co-ordinated permanent secondary work, much difficulty will be found in satisfying the future topographic needs of many parts of the country.

As the industrial development of India proceeds, the future will bring demands for maps on special scales or of special areas and in the preparation of such the absence of permanent, systematically placed marks to serve as easily attainable bases for the work will be seriously felt. It is true that over certain parts of India the need for secondary triangulation is not pressing, *e.g.*, over a great part of South Punjab and the forest tracts of Central India, but after allowing for such parts, there still remain large expanses where the absence of permanent secondary triangulation is a serious defect, placing India at a disadvantage as compared with many other countries.

During the last twenty years, the principal framework of India has been extended in Burma and in Baluchistan and a connection with Russian triangulation has been effected in the north but, as has been said, scarcely anything, by force of circumstances, has been done by way of amplifying the old framework, of remeasuring the old base-lines with modern apparatus, or of measuring new lines for the adjustment of considerable extensions of triangulation.

These twenty years were marked by considerable activities in Europe and America. Between 1903 and 1912, France, Germany and Russia had

each measured nine new base-lines with modern apparatus; Italy, seven and Japan, two, Austria, Norway, Sweden, Switzerland, Roumania and Greece all measured new bases for the rectification of existing triangulation or the needs of new work. A considerable amount of triangulation was carried out in Europe, North America and Africa and, in a lesser degree, in Australia, South America and Japan. In France, indeed, a new network was constructed specially for the 1 : 50,000 scale maps it was intended to produce. France, also, executed triangulation of a high quality in Peru and Equador in order to strengthen the data on which rests our knowledge of the figure of the Earth. For the same purpose, Roumania, Austria and Bavaria undertook new geodetic operations for the completion of the arc from Brest to Astrakhan, and triangulation to supplement existing frameworks was executed in Germany, France, Switzerland, Russia, the Tyrol, Roumania, Norway and Sweden.

Relatively, India has been losing ground. The experience of Europe and America has been that as the development of the country proceeds there is an increasing demand for precisely fixed permanent marks and national surveys have frequently found it necessary to strengthen and amplify existing triangulation. India has been under the necessity of employing her small triangulation party in extending the principal framework over areas where, as yet, there was no triangulation at all but of which topographical maps were much needed and while, as has been pointed out above, the old marks were gradually suffering reduction in number, she has not as yet been able to undertake systematic work on a supplementary secondary network.

It is hoped that in the near future it will be possible materially to improve India's position by the measurement of new and some of the old base-lines (the last was measured in 1881) with modern apparatus acquired in 1914, to ascertain the relation between the old standard of length of India and the modern standards of Europe, and vigorously to continue operations on the framework of secondary triangulation.

Spirit-Levelling.—Spirit-levelling was begun in India in 1858 but not on a definitely co-ordinated system nor by a special agency. In 1874, General Walker, Superintendent of the Great Trigonometrical Survey, drew up a scheme for a well-conditioned, co-ordinated system of levels, covering the whole of India and adjusted to careful determinations of Mean Sea Level at selected points round the coasts. For the prosecution of this scheme, Tidal Observatories were established and a definite organization formed to undertake the investigation of tides, the determination of Mean Sea Level and the commencement of the great network of spirit-levelling. Since that time, operations have been steadily continued, but, until a few years ago, it was part of the policy regulating the spirit-levelling operations that the Survey of India should concern itself only with levelling of the highest degree of precision and the construction of the fundamental network covering India and that the execution of levels of inferior quality should be left to other agencies. But of recent years, owing, on the one hand, to increasing demands springing from the gradual development of the country

and, on the other, to the insufficiency of the fundamental network, as it then was, to meet these demands satisfactorily, the propriety of relaxing the rigidity of adherence to the policy came under serious consideration and it was eventually decided to endeavour so to design operations as to satisfy, as far as possible, the demands for levels of something less than high precision quality as well as to strengthen and amplify the fundamental network.

As a general principle, the Survey of India policy of concerning itself only with the scientific framework may have been correct, but it was not yet rightly applicable to India where, in spite of levelling operations having been in progress for more than 50 years, the lines of precise levels of the network were still at great distances apart owing to the magnitude of the area that had to be dealt with. It, thus, generally happened that when levels were required in any locality for engineering or industrial projects, it was found that the nearest precise bench mark was at such a great distance that to carry levels therefrom into the areas in which they were required, with the requisite degree of accuracy, a branch line of high quality would have to be run from some limb of the network. It was perhaps not necessary that this quality should be that of "high precision" but it had certainly to be superior to that of ordinary engineering levels. Engineering staffs were not, as a rule, equipped or trained to run levels of the required quality and the survey was faced with the alternative of setting its policy aside by concerning itself with a line of levels, the demand for which had arisen not from itself but from an outside agency or of allowing such outside agency to base its levels on an assumed datum, independent of and not co-ordinated with the scientific network of India. The difficulty arose from this network being still on much too large a scale and from engineering demands having developed before there was time to subdivide and amplify its meshes.

The result of the modification of policy has been that the operations now embrace two classes of levelling, one of "high precision" for the purposes of the fundamental network and the restoration of many of the old lines which, owing to the fugitive nature of the original bench marks, have been almost entirely lost and a second class of "precision" for the provision of accessible data to industrial projects as well as for the amplifying of the "high precision" network.

By the end of the season 1919-20, 30,247 miles of levels of "precision" and high precision had been run since the commencement of operations in 1858. The subsequent season, 1920-21, added some 2,600 miles to the total outturn.

Glancing at what has been done in Europe and elsewhere, we find that by 1912 (reports for later years were interrupted by the war and are not yet available),

France	had run	58,466	miles of primary levelling.
Germany	„	33,757	do.
Russia	„	21,417	do.
Japan	„	13,967	do.
Switzerland	„	2,784	do.

Such figures, however, give no clear idea of the density or "efficiency" of the respective level nets, that is to say, of the ratio between the length of level lines and the area of the country concerned. If, for the sake of comparison, we take the ratio given by India's level net at the end of 1919-20 as unit, we get the following figures representing the efficiency of other countries as they were in 1912 :—

Belgium	4·35	Portugal	2·71
Spain	2·59	Roumania	3·00
France	16·88	Russia and Siberia	0·12
Germany	9·53	Switzerland	10·24
Austria-Hungary	3·24	Algeria-Tunis	0·82
Denmark	7·82	Japan	4·70
Italy	1·06	Sweden	1·35
Holland	7·18	India	1·00

Relatively, India is low in the scale, but it will be remembered that over large portions of India, the density of spirit-levels need not be nearly as great as over others where, on the other hand, the levels ought to be particularly dense. But the former cannot be ignored entirely. It should be possible, without great difficulty, to carry levels into any part of the country, for however unimportant a region may appear to-day, by to-morrow, thanks to the extension of railways or irrigation, the discovery of mineral wealth or other causes, it may have acquired considerable value and demand spirit-levelled data, and spirit-levelling, to be useful, must be completed before demands for its data arise. The "efficiency" figures given above represent averages for the whole area. India's average figure should be raised, during the next twenty years, to about 3.

Gravimetric Surveys.—In 1852, the Surveyor General, Sir Andrew Waugh, brought to notice that in the amplitudes of the two northern-most sections of the Great Arc of India, there were discrepancies of about 5″ and 4″ between the computed and observed values, the observed value of the northern section being in defect, that of the southern in excess. These effects were attributed to the influence of the Himalayas.

Archdeacon Pratt of Calcutta, whose interest had been roused by the phenomenon, then calculated the theoretical values of the effects of Himalayan attraction and found that these were much larger than were required to explain the observed discrepancies of amplitude. Out of this result there gradually developed the idea of mountain compensation and the existence of irregular variations of density within the crust of the Earth, and it was concluded that before geodetic measurements could be usefully employed in the determination of the mean spheroid, a greater knowledge of the local effects of irregularities of density was necessary. This led to a criticism of Everest's Arc of India. Sir H. James, Superintendent of the Ordnance Survey, remarked that "if there had been a larger number of astronomical points in this Arc, they would have added very greatly to the weight of the determination of the Earth's figure" and much disquiet was aroused by Colonel A.R. Clarke's

conclusions that the value of the Indian Arc had been considerably diminished since the investigations of Archdeacon Pratt. At the same time the Superintendent of the Great Trigonometrical Survey, addressing Government, stated that the paucity of astronomical observations in India had been unfavourably contrasted with the number taken elsewhere. As a result, two survey parties were formed in 1863 for " the sole purpose of fixing the absolute or astronomical latitude of various trigonometrical stations at moderate distances all over the peninsula of India " and " to obtain a tolerably complete series whence to deduce an approximation to the amount of the deviation of the plumb-line from the normal of each of those stations and thereby gain some insight into the law of local attraction and that of the Himalayan mass."

Such were the beginnings of the investigation into the nature of plumb-line deflections which continued up to 1914, supplemented between 1865 and 1874 and after 1904 by pendulum determinations of variations in the intensity of the gravitational force. The propriety of combining pendulum determinations with plumb-line observations had been recognised from the middle of the 19th century, but, owing to the nature of the apparatus, the actual carrying out of such determinations was a matter of considerable difficulty, until the commencement of the 20th century when the half-seconds pendulum apparatus was devised. With such apparatus, the second period of pendulum operations in India began in 1904, supported by a resolution of the International Geodetic Conference in 1903, that it was most desirable that an exhaustive study of the intensity of gravity should be made in India, in the mountains as well as in the plains, in view of the fact that it was only by research work of this nature that an exact indication of the distribution of masses within the crust and the true shape of the geoid could be acquired.

By the end of the season 1913-14, the astronomical latitude and the plumb-line deflection had been observed at 302 stations and between 1904 and 1914, 113 determinations had been made of the intensity of the force of gravity.

To show how the number of deflection determinations compares with what had been done abroad up to 1912, the following statement gives the " density " figure for different countries on the convention that the density in the case of India is 1·00.

Denmark	20·29	Switzerland	37·12
Italy	4·94	United States of America	0·76
France	2·47	Japan	1·18
Austria-Hungary	3·24	India	1·00
Germany	10·53		

The actual density of latitude stations in India, represented here by 1·00 is one station per 6,000 square miles, still considerably below that in Europe.

It may be noted that, unlike that of the results of triangulation and levelling, the utility of plumb-line deflection determination is not affected by the surface conditions of the region in which the station lies. The deflections afford data upon which may be based conjectures as to the distribution of mass below the surface but, so far as we are aware at present, the surface conditions give

no indication of the particular manner according to which the invisible masses are arranged, nor of the importance of that particular arrangement. Leaving out of consideration certain definite gravitational problems, it cannot be said, at present, that in any one part of India the surface characteristics foreshadow a particular or an important sub-surface condition and that therefore deflection determinations should there be of greater "density." Consequently local "densities" should not differ much from the average and as there is no reason for supposing that the knowledge of sub-surface conditions in India will be of less value than that of other countries, the average for India should be of the same order as that considered desirable elsewhere. At the present time it is low compared with that of other countries; against India's one astronomical latitude determination in every eleven triangulation stations may be compared Egypt's Nile Valley triangulation with a latitude determination at every other station.

A similar paucity of results characterises also the gravity determinations at present. For the solution of the scientific problems before us and much more so for the investigation of the applicability of gravimetric determinations to the interests of industrial development, the number of results in India is too small. New methods and new apparatus have achieved much during the last eighteen years but, in a country of India's area, the building up of a series of pendulum determinations to the stage at which the work begins to be productive of sound teaching, either scientific or economic, is not to be effected under a considerable number of years.

The gravimetric work of the Survey of India, like that of other countries, can now, less than ever, be considered an isolated line of research. It constitutes a branch of geophysics whose problems overlap more and more those of geology and the two lines of investigation are dependent on one another for data and assistance in explaining phenomena. There is also held out the possibility of economic value.

In Hungary, the Eotvos torsion balance, for the determination of small variations of gravity, has been used to discover, in detail, the arrangement of sub-surface masses and to indicate favourable fields for oil prospecting and drilling and there is no reason to suppose that, as we gain experience by extending our investigations and by determining the characteristics of gravity over known deposits, it may not be possible, to-morrow, to locate coal and iron.

During the next several years, it is hoped that gravimetric research will be continued and will extend in greater detail over the Himalayas, the Gangetic plains, the coal field areas and the Salt Range, amplifying our knowledge and enabling us to derive a fuller return from work already done.

TIDAL OPERATIONS.

During the past year tidal registration by means of automatic gauges was carried out at the following ports :—

Aden, Karāchi, Bombay (Apollo-Bandar), Bombay (Prince's Dock), Madras, Kidderpore, Rangoon, Moulmein and Port Blair.

All the tide gauges have worked satisfactorily, and there have been no serious breaks in the tidal registration.

All the tidal observatories were inspected during the year and the gauges thoroughly overhauled and put into working order.

In addition to the automatic tidal registration at the nine ports named above, observations of high and low-water on tide poles were taken during day-light at Bhāvnagar, Chittagong and Akyab, with the object of testing the accuracy of predictions which were based on tidal registrations taken many years ago.

The Director, Inland Water Transport, Basrah, has continued to supply to this Department tidal observations taken on a tide pole at Basrah up till 11th March 1922, and thereafter these observations, taken on an automatic tide gauge at Margil, were supplied by the Port Officer, Basrah. On the basis of these observations, data for the preparations of tide tables for Basrah for the year 1922, were prepared and supplied to the National Physical Laboratory, Teddington, England. The predictions were received from the Laboratory in December 1921 and supplied direct to the Director, Inland Water Transport and Port Officer, Basrah, and the Director of the Royal Indian Marine, Bombay, in December 1921.

The tide predicting machine was brought out from Teddington to India in October 1921 and was set up in the office of the Superintendent of the Trigonometrical Survey, Dehra Dūn. The predictions of Tides and preparation of tide-tables for Indian Ports as well as for Basrah for 1923 are now undertaken entirely in India and the tables will shortly be published.

LEVELLING OPERATIONS.

Levelling completed in 1921-22.

During the season 1921-22, the following lines of precise levels were run :—

A.—In the Bombay Presidency.

1. (*a*) Viramgām to Navānār, *viâ* Rājkot, Jorya and Shikārpur (Cutch) (Revision, originally levelled in 1874-76).

   (*b*) Navānār to Nakhtarāna (Revision, originally levelled in 1889-90).

   (*c*) Jacobābād to Shikārpur (Sind) (Revision, originally levelled in 1909-10).

   (*d*) Shikārpur (Sind) to Rohri (Revision, originally levelled in 1904-06).

   (*e*) Rohri to Reti (Revision, originally levelled in 1909-10).

   (*f*) Surat to Dhūlia (new line).

   In all about 721 miles of " high precision " levelling was done on the " fore and back " system for the new level net. In addition to redetermining the heights of the old benchmarks new benchmarks were established on short branch lines at the request of the Geological Department.

II. (*a*) Shikārpur (Sind) to Kambar.

(*b*) Wāriāso to Rato-Dero.

(*c*) Madad Chāndia to Mehar.

(*d*) Ruk to Sehwān.

(*e*) Daur to Lundo.

(*f*) Shāhpur to Mahrābpur.

(*g*) Tando Alāhyār to Hyderābād.

(*h*) Rohri to Jam Sāhib.

In all about 890 miles of new level line on the old system of simultaneous double levelling. The work was undertaken for the Sukkur Barrage Project.

III. (*a*) Nāndgaon to Ahmadnagar *viâ* Manmād.

(*b*) Sholāpur to Bijāpur *viâ* Jhalki.

(*c*) Batghar to Jhalki *viâ* Nira Bridge.

In all about 360 miles of new level line of simultaneous double levelling.

The work connects two old level lines and provides heights of benchmarks required by the Irrigation Department in connection with the Nira Right Bank Canal.

B.—In the United Provinces.

(*a*) Jhānsi to Saugor.

(*b*) Garhmuktesar to Alīgarh.

In all about 160 miles of simultaneous double levelling undertaken to provide cross-connections between two old level lines.

C.—In the Punjab and Rājputāna.

(*a*) Reti to Jhang, *viâ* Khānpur, Bahāwalpur and Multān (Revision of old Main line originally levelled in 1860-61 and branch lines levelled in 1909-15).

(*b*) New level line Khānpur to Islāmgarh and on through Jaisalmer and Jodhpur States to Mārwār Pāli *viâ* Jaisalmer, Khodyal, Sheo, Barmer, Balotra and Luni Junction.

In all about 722 miles of "high precision" levelling on the "fore and back" system undertaken for the new level net.

D.—In Bengal.

(*a*) Calcutta to Chuādānga *viâ* Bārāsat, Husainābād Jessore and Jhenida

(*b*) Jessore to Bārāsat.

(*c*) Dhuliān to Jangipur (for the Nadiā River Project).

In all about 310 miles of simultaneous double levelling undertaken for the Irrigation Department.

E.—In Bihār and Orissa.

(*a*) Jhārsugrā to Purūlia (to connect two old level lines).

(*b*) Tinpahār to Berharwa (for the Nadiā River Project).

In all about 229 miles of simultaneous double levelling.

F.—In the Central Provinces.

51 miles of simultaneous double levelling from Jhānsi to Saugor to connect to old level lines.

G.—In the Punjab and Kashmīr.

From Wazirābād to Anantnāg (Islāmābād) *viâ* Siālkot, Jammu, Dausal, Rāmban and Banihāl Pass.

In all about 207 miles of simultaneous double levelling were undertaken in order to complete the circuit of levels taken into Kashmīr, *viâ* the Jhelum Valley cart road in season 1912-13, an important mountain circuit.

GEODETIC PUBLICATIONS

BY

MAJOR C. M. THOMPSON, I.A.

Survey of India.

An important contribution to geodesy during the year under review was the Survey of India Professional Paper No. 18 by Lieutenant-Colonel H. McC. Cowie, R.E., entitled "A criticism of Mr. R. D. Oldham's Memoir—The structure of the Himalayas and of the Gangetic Plain, as elucidated by Geodetic observations in India."

In the outer Himalayas and in the plains at their foot, geodesists have long been confronted with problems arising out of the observed gravitational anomalies. The situation in respect to this problem is briefly explained in the opening lines of this Paper. "Along the southern fringe of the Himalayas, where they rise abruptly from the plains, and in the Gangetic Plain itself, the force of gravity has been found to possess, in respect to intensity and direction, marked peculiarities whose meaning has, for long, been the study of geodesists. Neither Bouguer's nor Hayford's hypothesis completely explains the observed facts."

"The Bouguer hypothesis fails completely to account for the facts observed in the Himalayas Gangetic region. Hayford's hypothesis, though it goes far towards interpreting them, still leaves us with unexplained residuals that can not be justifiably considered as accidentals, due to purely local departures from the general law, until it has been shown that modifications of the initial hypothesis will not produce a closer agreement between the calculated and observed quantities. As based on this hypothesis the

theoretical values of deflection as compared with the observed, at stations in the Himalayas and immediately at their foot are *too small* towards the north while over north-west, north-central and north-east India at distances of more than about 30 miles from the hills, the values are *too large* towards the north. This characteristic of the Hayford quantities and the magnitudes of the residuals may still require some modification before we accept them as the best approximation to the general law governing the actual distribution of densities in India."

Mr. R. D. Oldham, however, in his Memoir*—"The structure of the Himalayas and of the Gangetic Plains, as elucidated by Geodetic observations in India" puts forth the view that a reconsideration of the hypothesis is not necessary, and appears to be of the opinion that it is unnecessary to look further than the Gangetic Trough filled with alluvium for the explanation of the anomalies of the plumb-line deflection and intensity of gravity. He, accordingly, directs his investigation towards an estimate of what the dimensions of this trough ought to be to suit the geodetic determinations throwing into the background the consideration of other allied issues without a knowledge of which, the deflection and gravity anomalies, as they now stand, are not calculated to give reliable quantitative results as to the structure of the trough.

The method of calculating theoretical effects adopted by Mr. Oldham is of doubtful validity. To derive effects of masses he has substituted an imaginary Range for the real Himalayas and has restricted his calculations to masses within a distance of 100 miles only from the station, omitting from consideration the masses beyond as of no consequence, on the assumption that the effects of such masses, when coupled with complete local compensation, are negligible and has assumed that the Gangetic Trough itself is not compensated. This is not in conformity with facts. Table IV on page 23 clearly shows that the effects of masses beyond 100 miles and which have been disregarded by Mr. Oldham, are considerable and vary from 29″ to 65″ showing a range of 36″.

A perusal of the tabular statements on pages 29 and 30 will show the error to which the supposition of the Imaginary Range leads.

Further, for simplicity of computation, Mr. Oldham has introduced other innovations such as "centre of effect," "Concentration of mass"—conceptions which, though perhaps applicable to masses within short distances, are entirely out of place in investigations involving masses covering many thousands of square miles. He has, moreover, overlooked other rigorously determined Geodetic facts which are inconsistent with his theory.

Mr. Oldham based his theory of overcompensation on Basevi's incomplete gravity determinations at More and the faulty latitude-observations at Gogipatri and Poshkar.

Mr. Oldham's treatment of the Gangetic Trough is somewhat different from his treatment of other masses. For general purposes he limits the area

* Memoirs of the Geological Survey of India, Vol. XLII, Part 2, Calcutta 1917.

to be considered to the 200-mile square, arguing that the effects of masses outside this limit, when combined with those of complete compensation are negligible. But as he subsequently considers the alluvium of the Trough to have no compensation, the argument and the imposing of the 100-mile limit are inapplicable to the trough and the omission to take count of this would lead to error. On page 32 of his paper Colonel Cowie has calculated the effects of alluvium for a large number of stations on the assumption (1) that it is compensated, (2) that it is uncompensated, and also the total deflections with and without the trough. An inspection of this table will show that the introduction of the trough has not had the effect of removing the abrupt change in the residuals along the northern fringe of the Gangetic plain. There still exists between Dehra Dun and Kaliana, Birond and Bansgopal, Siliguri and Jalpaiguri the rapid variation which contributed to the evolution of Sir Sidney Burrard's rift theory. There is no marked general improvement and the characteristic anomaly, the rapid fall in the value of the residual, remains unexplained, a problem still awaiting solution.

ASTRONOMICAL LATITUDES.

During the year under review, astronomical latitudes have been observed at Gogipatri, Poshkar, Zebanwan and Reban. The previous observations made at the first two stations in 1862 were considered below the standard of precision required for geodetic purposes and have accordingly been repeated. The results of the observations are now being computed and must be held over for discussion in next year's report.

MOUNT EVEREST EXPEDITION.

The scientific results of the expedition have not yet been fully worked out but in general outline some 13,000 square miles of new country have been surveyed and mapped, part of this by the "Canadian photo-topographical method of survey."

BOTANY

I.—BOTANICAL SURVEY

BY

LIEUT.-COL. A. T. GAGE, I.M.S.,

Director, Botanical Survey of India.

I. Systematic.—Eastern India and Burma.—The most important event of the year with regard to the botany of Eastern India is the appearance of Parts I and II of the Botany of Bihar and Orissa by Mr. H. H. Haines, C.I.E., late of the Imperial Forest Service. The two parts now published contain the account of 76 families from *Ranunculaceæ* to *Cornaceæ*. The work is a valuable addition to the provincial Floras of India. In Bengal Professor Bose has studied the geographical distribution of the species of *Polyporaceæ* found in that province and has described several new species. The species of *Dipterocarpus* occurring in the Chittagong District have been studied and form the subject of a paper by Mr. and Mrs. Cowan of the Imperial Forest Service. In Assam Mr. Kanjilal carries on his investigation of the forest vegetation in preparation for the publication of a Forest Flora of that province. In Burma attention continues to be given to the botany of the Cinchona area in Tavoy and collections are being steadily accumulated by Mr. P. T. Russell, Superintendent of Cinchona there, as his other duties permit. It is all the more fortunate that Mr. Russell is taking up this work, as owing to lack of funds it has been impossible to depute any of the Assistants of the Botanical Survey for field work. The latter however are working up at head-quarters as opportunity permits the collections made by Mr. Russell and the Director. A considerable number of new orchids have been described by Mr. W. W. Smith, from collections made in Upper Burma and the Burmo-China frontier by Mr. G. Forrest, Captain Kingdon Ward and the late Mr. R. Farrer. New species of *Phtheirospermum* and *Pedicularis* from the same region have been published by Mr. G. Bonati. A new genus of Moss—*Chionoloma*—founded on material collected many years ago by Parish at Moulmein, has been described by Mr. H. N. Dixon. During the year 1921 Mount Everest Expedition collections were made by Mr. A. F. R. Wollaston which have yielded several new species, that have been described by various botanists.

Northern India.—An interesting illustrated account of the Forest formations and successions of the Sat Tal valley in the Kumaon Himalaya has been published by Mr. L. A. Kenoyer. The Liverworts of the Western

Himalaya continue to be investigated by Mr. S. R. Kashyap. The *Astarga* of the Subgenus *Aegacantha* form the subject of a paper by Mr. R. N. Parker of the Imperial Forest Service and a considerable number of new species from the North-West Himalaya has been published by the same botanist and by Mr. S. T. Dunn. In Nepal collections were made by Dr. S. P. Agharkar and Professor R. S. Inamdar.

Western India.—Mr. L. J. Sedgwick, I.C.S., has published several new species of flowering plants from the Bombay side, and a collection of Mosses made by him in North Kanara has formed the subject of a paper by Mr. H. N. Dixon. An ecological study of Deccan grassland has been made by Messrs. W. Burns and G. M. Chakradev. The vegetation of Northern Gujarat has been further investigated by Mr. W. T. Saxton, I.E.S., and his results are now in the Press as a number of the Records of the Botanical Survey.

Southern India.—Since last year Part IV of the Flora of the Presidency of Madras by Mr. J. S. Gamble, C.I.E., F.R.S., has appeared, containing the Families *Rubiaceæ* to *Ebenaceæ*. Supplementary Note No. IV on the Flora and descriptions of new species from the south of India by the same author have also been published. A new species of grass from Coimbatore has been described by Messrs. K. Rangachariar and C. Tadulingam and a new genus of Moss from the Nilgiris by Mr. H. N. Dixon. Mr. K. Rangachariyar, the Madras Government Systematic Botanist, has published a handbook of some common South Indian Grasses and a second edition of his Manual of Botany. Mr. Jacob, his Assistant, made a collection in the Tinnevelly Hills. As usual, material was supplied to Mr. Gamble to help in the preparation of his Flora of Madras.

General.—Mr. T. S. Sabnis continued his investigation of the physiological anatomy of the plants of the Indian Desert and Mr. P. F. Fyson his account of the Indian species of *Eriocaulon*. Professor Hallberg has recorded several instances of malformations in various Indian species. A revision of the genus *Canavalia* has been published by Messrs. C. V. Piper and S. T. Dunn. The flowering of *Arundinaria falcata* is the subject of a paper by Mr. J. S. Gamble. Short general accounts of the Family *Winteraceæ* and of the genera of *Fumariaceæ* have been published by Mr. J. Hutchinson. Asiatic Sedums have been studied by Mr. R. L. Praeger and a considerable number of new species described. Mr. H. H. Haines has published critical notes on the Indian species of *Carissa* and *Bridelia*. The Indo-Malayan species of *Jussiæa* have been studied by Mr. H. N. Ridley. Messrs. R. N. Parker and B. L. Gupta continue to publish their useful index to new Indian species of Forest importance. The first instalment of the systematic account of the *Euphorbiaceæ* of the Malayan Peninsula by the Director of the Botanical Survey has been in the Press for many months now and descriptions of the new species were published during the year in the Records. The species of *Artemisia*, a genus of economic importance as the source of Santonin, were studied at Kew by Mr. C. C. Calder, Curator of the Herbarium of the Royal Botanic Garden, Calcutta, while he was on leave. Mr. P. M. Debbarman, Assistant in the Botanical Survey, contributed five papers on various branches

of Botany to the last meeting of the Indian Science Congress and has published notes on Syncarpy in various species of Indian plants.

II. Economic.—By far the most important work under this heading is Cinchona Cultivation in Southern Burma. As it would take up too much space to mention in detail all the work of the year and as detailed monthly reports are submitted to Government, only a general account is given here. The results so far obtained have been instructive, if not so satisfactory as could be desired in every respect. As the site selected early in 1920 for establishing nurseries was found on account of the excessive rainfall and high winds to be unsuitable for planting out the seedlings in the open, the latter were planted out about 4 miles to the South-East of the Huingye Taung amphitheatre—the site of the nurseries—on the Southern flank of the most South Westerly tributary of the Heinze river at an elevation of about 1,700 feet. Planting out could not be commenced until near the end of May 1921 and was continued throughout June. As a result of the unavoidable lateness in planting out the young plants had not time to consolidate their position in their new quarters before the full fury of the Monsoon burst upon them. As the South-West end of the valley acted as a funnel for the Monsoon current the young plants fared badly. The rainfall can be described only as terrific. During June, July and August of 1921 over 240 inches of rain fell, some of the falls being from 11 to 16 inches in twenty-four hours. More than half the tender young plants succumbed to the ordeal. Those that survived, however, put on excellent growth and up to the time of writing (July 1922) a year later are quite healthy and growing well. The vacancies were filled in at the end of the rains of 1921 and planting extensions were continued as weather conditions permitted up to May 1922. Of the later plantings from October 1921 to May 1922, those plants planted out up to the end of January 1922 are at the time of writing quite healthy and putting on good growth, but those planted out later than January 1922 have had to withstand a scarcity of rain during the early months of 1922 followed by a very heavy Monsoon rainfall, and it is probable that a considerable percentage of them will be unable to hold out over the Monsoon.

Although the experience so far gained shows that Cinchona, if planted out at a favourable time of the year can stand up against the enormous rainfall—which is far more than was ever expected— of the present plantation site, which appears to be the point of impact of the very arrow-head of the Monsoon, it is inadvisable to continue to expose young plants to more risks than are unavoidable. As the rainfall further South in the Tenasserim Division of Burma is not only considerably less in amount but is also less unevenly distributed over the year than is the case in the Tavoy District, it would be preferable to select another plantation site or sites considerably to the South of the present one, say in Mergui District, where there are enormous tracts of virgin evergreen hill forest land available rather than to continue to take risks that are unavoidable on the present area in Tavoy District. Proposals for taking action on these lines will be submitted to Government at an early date.

In addition to Cinchona, the cultivation of Ipecacuanha has also been experimentally started in the Cinchona area. The latest report—received in August 1922—states that the Ipecacuanha plants planted in 1921 have made very fine growth. The climate of Southern Burma being as regards temperature more equable than that of the Eastern Himalaya, Ipecacuanha is likely to flourish in Tenasserim, while it has not to run the risks of being exposed to the direct battering force of exceedingly heavy rain, as it is a small plant and is cultivated in protected nurseries. The extremely arduous pioneering work of exploring and opening up under very trying conditions has been carried out throughout the year by Mr. P. T. Russell, the Superintendent, whose energy and zeal have formed an essential factor in the knowledge so far attained and call for the highest commendation.

At headquarters a large number of minor economic inquiries—too numerous to mention here—from other Government departments, Botanical institutions in India and abroad, Universities and private individuals were dealt with.

IV. Publications.—During the year the following parts of the *Records of the Botanical Survey* appeared:—Vol. VIII, Nos. 2 and 3 being the continuation of the *Flora Arabica* by the Rev. Father E. Blatter, S.J.; Vol. IX, No. 1, *A Survey of the Flora of the Anaimalai Hills* by Mr. C. E. C. Fischer, I.F.S.; Vol. IX, No. 2, *Euphorbiaceæ novæ e Peninsula Malayana* by A. T. Gage. A list of the more important extra-departmental publications concerned with Indian Botany is appended to this report.

BOTANY

II.—ECONOMIC BOTANY

Part I.—Agricultural Botany

BY

ALBERT HOWARD, C.I.E., M.A., A.R.C.S., F.L.S.,

Imperial Economic Botanist.

The present report, which is limited to four pages of print, deals with the progress of Agricultural Botany in India during the year ending June 30th, 1922. Under these conditions, the best course would appear to be to limit this paper to an account of the more important results published during the year and to refer the student of Indian agriculture for further details to the various other annual reports and periodicals issued by Government which deal with the same subject but in greater detail.

The following publications contain a considerable amount of information on the improvement of crops :—

(*a*) *Review of Agricultural Operations in India.*—This is an annual report, prepared by the Agricultural Adviser to the Government of India, Pusa, Bihar, and deals, among other matters, with the distribution of improved seed in various parts of India. It also contains a classified list of papers on Indian agriculture published during the year.

(*b*) *Scientific Reports of the Agricultural Research Institute, Pusa* (including the Report of the Sugar Bureau) :—Copies can be obtained from the Director, Agricultural Research Institute, Pusa, Bihar.

(*c*) *Administration Reports of the Provincial Departments of Agriculture.*—Bombay, Bengal, Madras, Central Provinces, United Provinces, Punjab, Bihar and Orissa, Assam and Burma. These are issued by the Government presses in these Provinces towards the end of each year and contain a general summary of the work of the Agricultural Department (including the farm reports) and also the annual reports of the Economic Botanists. These administration reports largely form the basis of the annual *Review of Agricultural Operations in India.*

(*d*) *Proceedings of the Board of Agriculture in India.*—This contains the programmes of work in progress in Economic Botany as well as discussions on matters relating to the Agricultural Department as a whole. Copies can be obtained from the Agricultural Adviser to the Government of India, Pusa, Bihar.

(*e*) Many of the original papers on Agricultural Botany in India are published in the following periodicals :—(1) *Memoirs of the Department of Agriculture in India* (*Botanical Series*), (2) *Bulletins of the Agricultural Research Institute, Pusa* and (3) *The Agricultural Journal of India.* This latter contains classified lists of all papers published on Indian agriculture. Copies of these publications can be obtained from the Director, Agricultural Research Institute, Pusa.

Cotton.—B. C. Burt and Nizamuddin Hyder (*Pusa Bulletin 123*) have carried out a survey of the cottons grown in Bundelkhand. The best of the types most suitable for field conditions has a lint length of about seven eighths of an inch and an average ginning percentage of 33. This cotton is being brought to the notice of the cultivators and in 1920 the area was 1,000 acres. B. C. Burt (*Pusa Bulletin 126*) has also published an account of further field and spinning trials of improved Cawnpore-American cotton in the United Provinces. G. R. Hilson (*Agr. Jour. of India, XVI, 564*) finds Balls' maximum combed length method suitable for the determination of the lint length of Indian cottons. M. L. Patel (*Mem. of the Dept. of Agr. in India, Bot. Ser. XI, 75*) gives a detailed account of *goghari* cotton and has defined the ideal type of *herbaceum* for Lower Gujerat. In a bulletin published by the Bombay Agricultural Department, G. L. Kottur has dealt with the history, cultivation and improvement of Dharwar-American cotton.

Two other matters, which affect research work on this crop, have to be recorded. A Royal Charter has been granted to the Empire Cotton Growing Corporation whose functions include the provision of facilities for training future investigators, the strengthening of the Agricultural Departments of the Dependencies and Colonies, the establishment of a bureau for the dissemination of information on cotton growing and assistance in the marketing of the crop. The Corporation will be financed by means of a Government grant of £1,000,000 and by a levy on the raw material used in Great Britain. In India, a Central Cotton Committee, with headquarters at Bombay, has been constituted by the Government of India for the purpose of carrying out the work outlined in paragraph 261 of the recent Report of the Indian Cotton Committee. The Central Committee has already held a number of general meetings, has appointed a research sub-committee and proposes to carry out research work on the improvement and testing of cotton. Local Cotton Committees have since been formed in several of the Provinces.

Wheat.—O. T. Faulkner (*Agr. Jour. of India, XVI, 508*) has reviewed the various field trials and milling tests carried out since 1915 on Punjab 11 and 8A. These two wheats are very similar as far as yielding power is con-

cerned but Mr. A. E. Humphries considers that the grain quality of Punjab 11 is the better of the two. According to the last Administration Report of the Punjab Agricultural Department, the area under Punjab 11 is now over 634,000 acres. This variety was included in the twenty-five types of Punjab wheats selected by the Botanical Section of the Pusa Institute and handed over to the local Department for field trials in 1908. Punjab 11 has so far proved to be the best of these wheats for the Canal Colonies. The methods employed in the introduction of Pusa 12 and Pusa 4 in the Central Circle of the United Provinces are dealt with by B. C. Burt, A. Howard and G. L. C. Howard in Pusa Bulletin 122. The features of this undertaking are, firstly, the extent to which the co-operation of other Departments and of the people themselves has been secured in the work of seed distribution and secondly, the comparatively small cost of the work. The area under Pusa wheats in the United Provinces is now over 500,000 acres and the increased profit to the growers is at least Rs. 15 an acre. This works out at 75 lakhs a year for this Province alone. The various water saving experiments carried out during the last few years at Quetta, Mirpurkhas, Gungapur, Haripur, Sargodha and Shahjahanpur have been dealt with in Pusa Bulletin 118.

Sugarcane.—The principal item for record in the case of this crop is the publication of the *Report of the Indian Sugar Committee*, the members of which made extensive tours in India and also visited Java. The report contains a number of suggestions and proposals with regard to future research work on this crop and lays great stress on the importance to India of the improved methods of cultivation worked out at the Sugar Experiment Station at Shahjahanpur. Two papers have been published on this crop during the year. Jai Chand Luthera (*Agr. Jour. of India, XVI, 519*) described two species of *Striga* found damaging cane in the *bet* areas alongside the Sutlej in the District of Ludhiana. T. S. Venkataraman (*Agr. Jour. of India, XVII, 127*) finds that the viability of sugar cane pollen can be tested by germinating it on the living stigmas of *Datura fastuosa* var. *alba* and that pollen can be preserved for eleven days by preventing the dehiscence of the anthers. A new variety of cane, Shahjahanpur No. 10, has been found to resist frost in Queensland.

Water hyacinth.—K. McLean (*Agr. Jour. of India, XVII, 23*) gives an account of this pest in the delta of the Ganges and of the methods adopted in Bengal and elsewhere for its eradication. The Bengal Government has appointed a Committee, with Sir Jaghadis Chunder Bose, F.R.S., as Chairman, to enquire into the spread of the water hyacinth and to suggest measures for its eradication. It will be interesting to find whether there is any connection between the spread of this weed and the local drainage conditions in the Gangetic delta. It may be that the root of the trouble is not the weed itself but the falling off in efficiency of the natural drainage in certain areas of Bengal which in turn would provide favourable conditions for the rapid vegetative propagation of a plant of this character. Should this prove to be the case, artificial methods of eradication by themselves are likely to be inadequate. That there may be a connection between the spread of the water hyacinth and the life history of the local rivers is supported by the fact that 1917, a

year of high floods and therefore of good natural drainage, was followed by a reduction of the pest in 1918 and 1919. Silt bearing rivers are remarkable in the way they keep their beds free from vegetation during the rains.

Jute.—Nibaran Chandra Chaudhury has published a new edition of his book *Jute in Bengal* in which he gives an account of his discovery, in 1899, of the variety known as *Kakya Bombai*, which yields on the average about two maunds of fibre more than the average. In 1919, the area under this type, was said to be 100,000 acres. B. C. Burt and R. S. Finlow (*Agr. Jour. of India, XVI, 618*) described preliminary experiments in jute cultivation in the *ganjar* tracts of the Sarda and Gogra rivers. Provided suitable land is selected and proper care is taken in cultivation and retting, marketable jute can be profitably produced in this tract.

Rice.—G. P. Hector (*Mem. of the Dept. of Agr. in India, Bot. Ser. XI, 153*) gives an account of the inheritance of the various colour characters in rice including those due to soluble pigment in various parts of the plant, the colour of the grain and of the inner glumes. Many of these characters are found to be inherited in groups or patterns and not independently. S. K. Mitra (*Agr. Jour. of India, XVII, 248*) describes simple methods of selection practised by the cultivators of Assam. S. K. Basu (*Agr. Jour. of India, XVI, 69*) has dealt with an interesting method of green manuring broad casted paddy in Orissa by means of *dhaincha* (*Sesbania aculeata*). S. S. Salimath (*Bull. 107, Bombay Dept. of Agr.*) describes a wild rice found in drilled paddy in certain parts of the Bombay Presidency.

Barley.—W. Youngman (*Mem. of the Dept. of Agr. in India, Bot. Ser. XI, 714*) has completed interesting experiments on the influence of atmospheric conditions on the germination of barley. A vapour pressure of 0·87 inches (0·0213 grm. of water vapour per litre of air) may be taken as the safest maximum to which Indian barley intended for malting may be exposed. Vapour pressures above this at first reduce and then totally destroy he germinating power in a comparatively short time. In practice this means that after May in North-East India it is not safe to ship malting barley to Europe by way of Calcutta without the risk of serious damage in transit.

Oil seeds.—C. S. Taylor (*Pusa Bulletin 117*) has given an account of various preliminary experiments carried out at Sabour on the influence of the environment on the oil content of various varieties of the castor oil plant. A. Howard and J. Stewart Remington in Pusa Bulletin 124 describe the work done on safflower oil and its possible utilization in the arts. The conclusion is drawn that this oil should become a very useful economic product for the colour, paint and varnish industries, for soap and linoleum manufacture and for edible and culinary purposes.

Miscellaneous.—H. H. Mann (*Bull. 100, Dept. of Agr. Bombay*) has brought together, in a form very useful for future workers, a large amount of information on the fodder crops of Western India. W. R. G. Atkins in the issue of *Science Progress* of July 1921 has given an account of past work on indigo in Bihar and of his views on the impracticability of improving this crop

by chemical selection. S. H. Prayag (*Agr. Jour. of India, XVII, 41*) describes various methods of increasing the yield of grapes in Western India. A. T. Gage in the last report of the Cinchona Plantations in Bengal refers to the excellent results obtained at Munsong after coppicing various species of *Cinchona*.

BOTANY

II.—ECONOMIC BOTANY

Part II.—Forest Botany

BY

R. S. HOLE, C.I.E., F.C.H.,

Forest Botanist.

Oecology of Sal (Shorea robusta).—A summary of most of the experimental work carried out up to date on the factors influencing the development of sal seedlings was published during the year (*Indian Forest Records* Vol. VIII, Part II, 1921). Based on these results an experimental trial with a group-*cum*-strip system of regeneration was suggested for certain types of sal forest. This system possessed two features which rendered it troublesome to work on a large scale, *viz.* :—

(1) the prescription that only alternate strips should be regenerated, the regeneration of the intervening strips not being undertaken until the second half of the rotation.

(2) the prescription regarding a chess-board arrangement of patch fellings which are gradually extended in the form of strips.

The object of (1) was to insure as complete security as possible from drought and frost damage, by the provision of adequate side-shade both from the east and west, and of (2) to diminish damage by heavy weed growth. An inspection during the year of one of the Dehra Dun experimental areas, 180 feet in diameter, which was clear felled in 1915 and sown with sal in patches revealed the fact that the seedling growth here now was much more satisfactory than appeared probable at first. The seedlings here suffered considerably from drought during the first few years but now, after 6½ years, several have become thoroughly established with height growth attaining 5-8 feet. This, it is believed, justifies the conclusion that the more convenient system of continuous strip fellings (which will always insure side-shade from at least one direction) can be safely adopted instead of that of alternate strips. In the second place, it is probable that, as suggested by Mr. C. G. Trevor, weed growth can be sufficiently controlled by varying the width of the strips instead of by a chess-board arrangement of felling. With the co-operation of local officers in the United Provinces large scale tests of strip fellings on these

modified lines have been carried out during the year in the Dehra Dun and Haldwani Divisions.

The only factor which at present appears likely to militate against the success of the system is damage by rats. In the Dehra Dun experiments these animals have been responsible for very heavy mortality among the young sal plants by biting through the sappy tap roots of vigorous seedlings and saplings. As mentioned in last year's report, however, it is believed that this damage will be relatively unimportant when work is carried out on a larger scale. During the year, also, it was noticed that rat damage appears to be invariably worst where there is a heavy growth of grass especially of *Imperata* and large tufted species of *Saccharum*. The rats appear to be primarily attracted by the succulent rhizomes of the grasses on which they feed and incidentally they bite through the succulent sal roots which they come across in their burrowings in the grass. It is believed that grass growth and consequently rat damage can be adequately controlled by keeping the strips narrow, by allowing all good coppice growth to develop on the strips and form a part of the future crop and by sowing sal thickly and weeding during the early years, so that the seedlings may quickly form a close canopy.

The advantages of this strip system over the ordinary seeding felling method at present appear to be that it provides more suitable conditions of soil moisture for seedling growth, greater security against weeds, greater concentration and better control of artificial sowings and cultural work. It also avoids the damage to the young growth occasioned in seeding felling areas by the felling and export of the mother trees. At the same time the strips get the benefit of most of the natural seed produced by the trees on the edges of the cleared strips. Whatever success is eventually obtained with the strip system will be mainly due to Mr. C. G. Trevor, Conservator of Working Plans in the United Provinces, to Mr. E. A. Smythies, Sylviculturist, and to Messrs. H. G. Champion and M. P. Bhola, Divisional Forest Officers of Haldwani and Dehra Dun, who have heartily co-operated in the work of testing this system experimentally.

During the study of the oecology of sal which has been carried out in recent years it has frequently been noticed that the attacks of wood boring insects appear to depend greatly on the vigour of growth of the tree and on whether or not the "sap" in the tree is in active circulation. This to a great extent depends on the conditions of soil and soil moisture and these can be regulated to a considerable extent by the operations of practical silviculture. It is possible that an improvement of these conditions at seasons coinciding with particular stages of the life histories of such insects as *Hoplocerambyx spinicornis* in sal and the bee-hole borer in teak may materially reduce the damage done by these injurious pests. It is hoped that oecological work in this direction will shortly be developed in co-operation with the Forest Zoologist. The study of the effect of soil and moisture conditions in lowering the resistance of sal and sissu (*Dalbergia Sissoo*) to the attacks of the injurious fungi *Polyporus Shoreae* and *Fomes lucidus* was continued.

Systematic.—A matter the importance of which has become increasingly evident during the year is that of disseminating widely through all ranks of the Department a good practical knowledge of our forest species. The urgent need for an economic survey of forest resources is frequently emphasized by forest officers and the first step towards such a survey is to acquire a knowledge of the local species. It is not generally realised how much economic development is hindered by an insufficient knowledge of species on the part of local officers which makes it difficult to collect information regarding the local distribution and yield of commercial products and to obtain samples of them for research purposes. It is believed that two causes are chiefly responsible for this *viz.* :—

(1) a tendency which has been somewhat prevalent in the past to think that a forest officer who studies and tries to know well the plants in his forest is gradually becoming "only a botanist" and is therefore decreasing in value as a practical forest officer.

(2) the fact that the classical detailed floras now available in India, indispensable though these undoubtedly are, do not sufficiently facilitate the successful identification of species by the average forest officer.

As regards the first point, the idea appears to be due to a misunderstanding, on the one hand, regarding the lines of work which fall within the legitimate scope of the science of botany and on the other hand as to the kind of botany which an efficient forest officer ought to know. The decision as to the correct botanical name for any particular species or other group depends upon herbarium work and a study of the herbarium specimens, plates and original descriptions on which those groups are based and which are the authority for the various published specific and varietal names. Forest Officers, as a rule, have neither the time nor the opportunity for doing much work of this kind which should be done by the expert herbarium botanist. On the other hand, what is usually called field work which comprises a study of the living plants in the forest, of the characters which enable us to recognise them in the forest at different seasons of the year and of the range of variation which these exhibit forms a necessary part of forest botany and, to a more or less considerable extent, forms an essential part of the equipment of every efficient forest officer in India. A great deal could be done by those local forest officers who know their plants well in the way of helping other forest officers to increase their knowledge in this respect while if senior officers make it clear that they consider a good knowledge of local species necessary for efficiency it is believed that a considerable improvement would result.

As regards the second point, efforts have been made for many years to encourage forest officers who have studied their plants in the forest to prepare small simple floras, each one of which dealing with a small area and therefore a restricted number of species and in which forest characters are utilised as far as possible in the keys and descriptions. With the object of accelerating this work a scheme for the systematic preparation of descriptive lists of species was drawn up by the Forest Botanist in 1913 which subsequently received

the sanction of the Government of India (see *Forest Bulletin* No. 23, Calcutta, 1914). Descriptive lists of this kind provided with useful keys are really very efficient local forest floras and it is believed that such pocket companions for the field dealing with restricted areas will always possess a permanent value of their own. The first lists issued under this scheme were those for the 3 Forest Circles of the Central Provinces by Messrs. H. H. Haines and D. O. Witt which were published at Allahabad in 1916. Similar lists but in a preliminary form were under preparation during the year for the United Provinces by Mr. A. E. Osmaston and Mr. P. C. Kanjilal. This work has also been carried a definite stage further during the year by the completion of a local forest flora for the Andamans by Mr. C. E. Parkinson, a former forest student of Dehra Dun. Mr. Parkinson's work has materially increased our knowledge regarding the species of the Islands. Four new species have been discovered and more than 130 of the indigenous species described in his book either have not been mentioned at all or have not been reported as occurring in the Andamans in Brandis's *Indian Trees*. Mr. Parkinson's work has also indicated that several species which have been previously recorded for the Andamans probably do not occur in the Islands and that the well known Andaman Marblewood is not yielded by *Diospyros Kurzii* Hiern as has been hitherto thought to be the case. At the present time when methods of concentrated artificial regeneration are being extensively introduced into Indian forests, particularly in Burma and Bengal, it is especially desirable that forest officers should know their local species well and should have a good knowledge of the value of the products yielded by them so that steps may be taken to increase the proportion of the more valuable species in the regeneration areas, a point which has been drawn attention to by Mr. Shebbeare in Bengal. If this is not done it is possible that species of great potential value may be altogether eliminated from the forests. The following books were under preparation during the year: the *Flora of Bihar and Orissa* by Mr. H. H. Haines, a revised edition of the *Forest Flora of the Punjab* by Mr. R. N. Parker, a *Forest Flora and Descriptive Lists for Assam* by Rai Bahadur Upendranath Kanjilal, a revised edition of Lace's *List of Burmese Trees* by Mr. A. Rodger, of the *List of the Trees of the Bengal Duars* by Mr. E. O. Shebbeare, of Gamble's *List of Darjeeling Trees* by Mrs. Cowan and of a *Manual of Forest Botany* by the Forest Botanist and his staff. During the year 154 specimens were identified at Dehra Dun for inquirers and Mr. Parker, the systematic botanist, made a special study of *Dipterocarpus*, *Acacia* (groups *cæsia* and *eburnea*), *Berberis* and exotic species cultivated in India. Several excellent specimens of flowering bamboos were received from forest officers in Burma during the year. These include what is probably a new species and material which will considerably alter existing ideas regarding the limits of *Teinostachyum* and allied genera.

Pathology.—A careful study has been carried out by the Assistant Forest Botanist, Mr. Abdul Hafiz Khan, in co-operation with forest officers in Madras, with reference to the location and progressive accumulation of starch in the tissues of spiked sandal and the question as to whether truly spiked plants ever recover from the disease.

With the extension of plantations and the establishment of more or less pure crops over considerable areas there is a danger that the damage done in Indian forests by what are probably our most injurious fungi, *viz.* those which live in the soil and attack the roots, may increase in the near future but it is hoped to prevent this, on the one hand, by providing for the repeated and careful inspection of young crops so that the earliest attacks may be noticed and the infected trees and stumps removed with as little delay as possible and, on the other hand, by paying increasing attention to the soil conditions and seeing that, so far as possible, these are kept suitable for healthy root development.

BOTANY

II.—ECONOMIC BOTANY

Part III.—Mycology

BY

W. McRAE, M.A., B.Sc., F.L.S.,
Officiating Imperial Mycologist.

Agricultural Research Institute, Pusa.—The following is an account of the chief investigations carried out at Pusa during the year :—

Cereal Diseases.—*Piricularia oryzae* Br. et Cav. that causes a leaf spot and a discolouration and collapse of the haulm resulting in empty or partially filled ears of *Oryza sativa* (paddy) has been recorded from Baluchistan, Punjab, Bihar, Bengal in Northern India and from both the east and west coasts and the central area of Madras. Only in 1918 in Madras is it definitely known to have been epidemic but its having caused a small but noticeable amount of damage has been the reason for its collection in the other places. The loss in grain during the epidemic was as high as 90 per cent. in fields of an acre and 76 per cent. over 1,700 acres observed. The appearance of the disease is erratic. In the year after the epidemic in Madras the fungus was not found in the previously infected area though careful search was made for it during a period of two and a half months. Yet *P. repens* that is the common grass of the rice " bunds " and water channels was attacked by a *Piricularia* in a severe epidemic form. In Madras and Bihar fifty per cent. of the seedlings in the seed bed may be infected slightly and after being transplanted the plants may ultimately become almost free from disease. Infection experiments and the available meteorological records indicate that highly moisture charged air and a definite temperature are the limiting factors most concerned in deciding whether the disease is to be absent or cause slight or great loss. Species of Piricularia similar to that on the rice plant have been found on *Eleusine coracana, Panicum repens, Setaria italica, Paspalum sanguinale, Triticum vulgare* and *Panicum ramosum.* On the first two only has the fungus been found in epidemic form. The loss in grain in *Eleusine coracana* has amounted to 50 per cent. while *P. repens* is a wild grass of no economic value. Cross infection experiments indicate that the *Piriculariae* on *Oryza, P. repens* and *Paspalum*, though each infecting its own host, will

not infect the others and that those on *Eleusine*, *Setaria* and *Triticum* are interchangeable among themselves though they will not infect the three previously mentioned hosts. The *Piricularia* on *P. ramosum* has been but recently found and nothing is known of its behaviour. The question whether there are four physiological strains of one fungus or four different species is left undecided as yet. Their anatomical and cultural characters are not very distinct but their ability to infect different hosts under our conditions is definitely restricted. Similar indications are observed in the field. While rice plants were infected with epidemic violence, plants of *P. repens* remained free and *vice versâ*. *Eleusine* and *Setaria* growing in the same field were both infected as also Eleusine and *Triticum*. Of *Eleusine*, *Setaria* and *Paspalum* in the same field only the last was infected.

Two other diseases of paddy have been under investigation. One of them is caused by a sclerotial fungus which has not at present been identified. The sclerotia of this fungus are irregular brownish structures of considerable size (1—4 mm.) and this parasite is thus easily distinguished from the relatively commoner *S. Oryzae* Catt. It resembles in some respects the species *S. irregulare* Miy., which is known as the cause of damage in rice fields in Japan, and also the species *S. glumale* Ces., which has been recorded in Borneo. In India the parasite produces spots on the leaf sheath. These spots are very characteristic consisting of a light yellow brown area sharply demarcated by a dark reddish brown line. Under favourable conditions the fungus spreads over the whole plant which is speedily killed. The symptoms of the disease and the morphology of the parasite closely resemble those of a disease of sugarcane, which has been described in Java, under the name Djamoer Oepas, and has since been collected in India. Work is in progress to determine whether the causal fungus of the disease on paddy is identical with that on sugarcane.

The second disease of paddy is possibly caused by a species of *Cephalosporium*. The symptoms of disease in this case are a failure of the plant to produce grain. Paddy showing these symptoms, and infected with this fungus has been obtained from Burma and Assam and cases are recorded from the Central Provinces. It is as yet by no means certain whether the fungus which has been obtained in culture is the cause of the disease. It is not improbable that soil conditions may be the predominant factor in determining the incidence of this fungus as a parasite.

The smut (*Tolyposporium Penicillariae* Bref.) on *Bajra* (*Pennisetum typhoideum*) was investigated, at the request of the Director of Agriculture, Baroda State. This millet is one of the most important agricultural crops of the State and considerable annual loss in yield is caused by the smut. Preliminary experiments have shown that this disease is amenable to treatment. Plants from seeds treated with hot water at 60°C. for 10 minutes and with hot formalin vapour at 98°C. for 20 seconds gave considerably less number of smutted heads than plants from untreated seeds. Ordinarily the percentage of smutted heads is between 30 and 40 but the percentage was reduced to 8 and 15 in the case of the plants raised from seeds treated with hot water and

hot formalin vapour respectively. The seed treatment reduces a little the percentage of germination. Spraying flower-heads with Burgundy mixture and Lime sulphur and bagging the inflorescence from the time it was in the enveloping spathe to the time the seeds were set, had no effect in controlling the smut. The presence of the smut mycelium has been traced in seeds which look apparently normal; this confirms the field observations which had suggested that the disease was being carried in the seed. In seeds, not much infected, the mycelium is found in the scutellum and in the seed coat near the embryo.

Experiments on a field scale are being tried in the present season for controlling the smut by treating the seeds with hot water and with formalin and copper sulphate solutions. Hot formalin vapour treatment is not practicable for treating seeds on a field scale under our conditions, and so it is not continued this season. Seeds from Mirpurkhas and Lyallpur where this smut does not occur, are being tried at Baroda and Pusa.

Sugarcane.—A suspected outbreak of Mosaic disease of sugarcane in Sind was investigated and proved to be unfounded. Suspicious symptoms in two varieties—American D99 and Sathi at Pusa were also studied. Hypodermic injections from Sathi canes caused a discolouration of the leaves similar to that found in the leaves of suspected plants. Neither the "diseased" nor the infected plants were the worse for this discolouration.

The thick varieties of sugarcane are generally reported to be smut resistant, while the thin varieties are susceptible to the smut. While investigating the cause of this reported immunity of thick canes to smut, it has been observed that they are not necessarily smut resistant. The resistance of the following thick varieties—American D99, Sepaya, Malabar, Badela and Sathi—was studied and it has been found that they are susceptible to artificial infection; though in nature they are as a rule free from smut.

Jute.—Experiments to determine the influence of applications of sodium sulphate, as manure, on the growth of jute and the incidence of disease in the crop were continued throughout the year. The study of *Macrophoma Corchori* Saw. was continued both at Pusa and at Dacca. The fungus causes a stem rot of jute, similar to that already described as due to the attack of *Diplodia Corchori* Syd. The disease is most severe when there is a deficiency of potash in the soil. Applications of sodium sulphate appear to have had a considerable influence in reducing the incidence of this parasite. The spore stage of this fungus occurs only on the jute plant and in artificial culture the fungus remains sterile producing a small black sclerotia. This sclerotial form of the fungus appears to be identical with that previously described in India as *Rhizoctonia Solani* Kuhn.

Other Scientific Departments.

Madras.—Treatment of cholam seed (*Sorghum vulgare*) was carried out in Coimbatore, Bellary and Kurnool districts. Sufficient copper sulphate to treat seed for 46,000 acres was supplied to the ryots. The operations of

the Madras Agricultural Pest Act 1919 were extended to the Taluqs of Polavaram, Ellavaram and Chodavaram. Research work was carried out on *Helminthosporium* disease of paddy, *Vermicularia* attacking ginger, turmeric, chillies and cabbage and other diseases. The results of the investigations on *Vermicularia* on ginger were published.

A new series of spraying experiments on coffee were conducted during the past year with the object of reducing the cost of spraying against *Hemileia vastatrix* B. & Br. Evidence was obtained indicating that the incidence of the diseases Brown and Grey Blight of tea is more severe after attacks of *Helopeltis*. The prevalence of *Rosellinia arcuata* Petch on tea bushes is directly connected with the presence of decaying *Cinchona* roots in the soil of tea gardens. Removal of decaying stumps and roots of *Cinchona* combined with liming of the soil has proved efficacious in some estates. During the past year a Rubber Mycological Station was opened at Mundakayam and a Rubber Mycologist was appointed. The loss of rubber, due to the attack of *Phytophthora Meadii*, during the past season was, on an estate, estimated at 18—28 per cent.

Bombay.—The storage rots of the potato were investigated. The work was directed mainly to the determination of the characteristic effects of the various suspected physical and biological causes of the rots and evidence was obtained which throws considerable doubt on the correctness of identifying the "Heat Rot." previously described with the "Black heart" of American authors. The symptoms described as Heat Rot appear to be the combined effect of certain Fungi and bacteria acting vigorously at the high temperatures obtaining in potato storage. These symptoms are not produced when heat alone (even up to 42°C.) is allowed to act on the tubers in the absence of micro-organisms and they are found to occur at the lower temperature of 85°F. which has been previously regarded as a suitable temperature for checking "Heat Rot." Study of the temperature relations of the fungi associated with the rots further showed that some of them, *e.g.*, the Dry rot fungus, thrive best at 85°F. No treatment of tubers with fungicides is found to be effective in keeping out or destroying the rot fungi. The solution of the problem of potato storage has therefore to be sought in still further reduction of the temperature in storage.

The wilt disease of cotton was investigated and the races known as Dharwar 2 and Wagale showed considerable resistance to the disease.

Bengal.—The districts of Noakhali and Comilla were surveyed in order to find out the extent of the damage done to the paddy crop by ufra disease. On enquiry it was found that a decrease in the amount of disease had taken place. This is attributed to an improvement in drainage. The outbreak of bud rot on the palmyra palm in the districts of Burdwan and Hooghly was investigated. In some villages 300—400 trees have died in the last 6 years. As the palmyra-palm is not of much economic importance the inhabitants are not greatly concerned with the outbreak. The spraying of chilli against die back was carried out with satisfactory results.

Central Provinces.—A special enquiry into the smuts of jowar prevalent in the Province was made and propaganda for seed disinfection was commenced. A leaflet describing the method of treatment and a larger pamphlet were printed to assist in propaganda.

Assam.—An outbreak of early blight (*Phytophthora infestans*) on potato in Sibsagar was dealt with by spraying with Burgundy mixture. Bordeaux mixture was also used extensively for the same purpose on Shillong Farm.

AGRICULTURAL BACTERIOLOGY

BY

C. M. HUTCHINSON, B.A., C.I.E.,

Imperial Agricultural Bacteriologist.

Work was done at Pusa on the following subjects :—

Nitrogen fixation, symbiotic and non-symbiotic.

Nitrification in soils: relation of seasonal and controlled variation to crop development.

Green manuring.

Solubilisation of mineral phosphates and refractory organic manures by bacterial fermentation.

Treatment and use of cattle manure.

Sterilisation of water and milk; preparation of an indigenous antiseptic.

Indigo.—The use of pure cultures in its manufacture. Investigation and classification of types of hydrolysers from various sources.

Yeasts.—Study of types suitable for use in various Indian Industries.

Biological analysis of soils.

FORESTRY

Part I.—Silviculture

BY

CAPTAIN H. TROTTER, M.C.,

Silviculturist.

The year under report was of special interest in that it recorded an important step in the progressive history of Indian Silviculture. That step was the convening of the second Silvicultural Conference at Dehra Dun in January 1922. The agenda of the Conference was limited to matters of policy and organisation and much useful work was accomplished. It is not proposed to give a detailed account of the various subjects discussed at the Conference in this report as they will be published *in toto* at an early date. It is of interest to note, however, that the relation between the Local and Central Silviculturists mentioned in last year's report has now been satisfactorily defined. In future it is suggested that the Central Silviculturist will confine his activities to investigations connected with seeds and seedlings and all other experimental silviculture will be done by the Provinces themselves. In the matter of statistics the field work is to be done locally and all results are to be worked out by a special computing staff at Dehra Dun. This division of labour should undoubtedly tend to further efficiency and the mutual co-operation resulting from it will do much to stimulate research work in this important science.

Statistical Work.—During the year 18 existing Sample Plots were remeasured by the Central Institute on behalf of the United Provinces and many other plots were remeasured by the Local Silviculturist in the same province.

A great deal of time was spent in converting the various statistical data collected in the past, into the new form as prescribed under the present Code. This conversion from the old method to the new has been a long and tedious business and it is satisfactory to note that most of the Sample Plots records have been now brought up to date.

Two Volume Tables were compiled and published during the year both for Sal. The first concerns I Quality Bengal Sal only and the second contains a general Volume Table and Form Factors for the same species.

It was hoped that sufficient data would be collected during the year to prepare a Yield Table for Cedrus Deodara and with this end in view a hot

weather tour in the hill Divisions of the Punjab had been arranged but owing to the unsettled condition of the Province this tour had to be abandoned.

The following publications were issued from this Branch during the year :—

(1) Note on the Weights of Seeds by S. H. Howard, B.A.

(2) Note on the Rate of Growth of Bengal Sal by S. H. Howard, B.A.

(3) Code for the Collection and Compilation of Statistical Data with Appendices by S. H. Howard, B.A.

(4) Volume and Form Factors by S. H. Howard, B.A.

The Sal (*Shorea Robasta*).

The experiments dealing with the natural reproduction of Sal by the Gorakhpur method were continued in Thano Forest (U.P.) where frost damage is usually very severe.

It was unfortunate that this comparatively small area opened out in the centre of a large forest at once became the centre of the attraction to all deer and cattle in the neighbourhood and within a very short while every plant was nibbled down to 3 ft. or less. The area was fenced immediately and it is hoped that some reliable data will be forthcoming. This question of grazing would probably not occur on a large regeneration area and as grazing incidence was not the subject under experiment it was considered that fencing was quite legitimate in this case. Any small opening made in a dense forest is bound to attract animals from all round.

The results from the existing Sal Coppice Experiments are now being classified and the result will be submitted to the United Provinces Silviculturist for his opinion and if considered of sufficient interest will be published shortly. This question of Sal Coppice has been very thoroughly gone into by the United Provinces and it is understood that some reliable information will shortly be forthcoming.

The experiments on the storage of Sal seed were carried out on a large scale at the Central Institute at Derha Dun and the results will be published shortly. A short note on the transplanting of Sal seedlings raised in sawdust already appeared in the Indian Forester and it is hoped that a detailed account of the above experiment will be published during the coming year.

Afforestation.—The experiments in the afforestation of grassy blanks liable to heavy frost are being continued at Zabarkhet. It is too early yet to say whether root and shoot cutting of Sissoo (Dalbergia Sissoo) are preferable to line sowings of Chir (Pinus longifolia) or boardcast sowing of Sissoo.

All these methods appeared to be doing well up to date but no conclusions can be drawn until another hot weather and rains have passed. It is expected that something definite will be published during the coming year. It may be noted however that owing to the very severe drought in the abnormal hot weather of 1921 the root and shoot cuttings suffered a great deal and many

plants died off without shooting. Much better results might be expected in a normal year. The unweeded line sowings of Chir (Pinus longifolia) are so far looking extraordinarily healthy but it remains to be seen whether the young plants are able to endure the coming hot weather and rise above the vigorous growth of rank grass, which covers these areas during the rains. The broadcast sowings of Sissoo are most successful up to date and the area is covered thickly with young plants. It is now considered however that sowing broadcast is a mistake as no grass cutting can be done once the seedlings are established. In line sowings the difficulty is overcome and line sowings of Sissoo will be tried next winter. It may be mentioned that grass cutting pays for itself, the villagers being allowed to cut the grass and remove it for their own use. No weeding or irrigation has been done in any of the above mentioned experiments.

Experimental Silviculture.—This work is now done almost entirely by the provinces and it is impossible to detail the vast amount of experimental silviculture carried out by the provinces in this report.

The Central Institute has confined its activities to experiments dealing with seeds, germination, sowings and transplantings. A lot of useful information with regard to germination and the early growth of seedlings has been collected. Monthly height measurements have been started for the following six species, Shorea robusta, Terminalia tomentosa, Dalbergia sissoo, Acacia Catechu, Bombax malabaricum and Cedrela Toona. These will be published after one year's growth and will give an interesting idea as to the exact growing periods of these species. The nursery beds at Kaunli Experimental Garden are now being made 6′ wide instead of 4′, as heretofore. These wider beds are found to be more economical and practical and are the result of an interesting discussion which followed the reading of a paper on "The importance of Nurseries as an aid to success in the Taungya System" by Mr. L. E. S. Teague at the Silvicultural Conference. The beds are all protected from the direct rays of the sun during the hot weather by moveable sections of grass thatch. These have proved most beneficial to the young plants.

The most important work now being done at Kounli is the study of transplanting. Experiments on a large scale were started during the year with various species. Transplanting seedlings entire and with root and shoot cut back is being done both at the commencement of the rains and during the winter. Thus every species has 4 distinct chances and as 200 plants are used for each species, some reliable data on this important subject should be forthcoming at an early date.

The mass of information which has been accumulating in the ledger files at the Central Institute during the past few years is now being sorted and written up in concise form. It has not yet been decided in what form this information will be published..

The Camphor experiments were continued throughout the year and it is now considered that sufficient data is available to publish the result. This

note has been pepared in conjunction with the Forest Economist and rest Chemist and will probably be published during the coming year.

Development in Silvicultural Systems.—There is nothing of outstanding importance to record under this heading.

Several new working plans have been brought into force during the year most of which introduce or continue one of the many variations of the Uniform System.

The United Provinces have maintained the high Standard which was begun with the creation of the Working Plans Circle and other Provinces are now following suit. Burma and Bombay have already inauguated Working Plans Circles and Madras, Bengal, the Central Provinces and Bihar and Orissa have appointed special officers for Silvicultural Research during the year.

Miscellaneous.—It is satisfactory to note that the importance of Silviculture in India has at last been recognised. Silviculture must form the basis of forest management and it must therefore find expression in Working Plans, and the creation of new posts for Working Plans Circles and the appointment of no less than 5 Provincial Silviculturists during the year is sufficient evidence to show how rapidly Silviculture in India is coming into its own. The division of labour between provinces and the Central Institute is now more or less clearly defined and with the decentralisation of experimental silviculture and the centralisation of statistical work the standard of efficiency should rise rapidly and the effects of such a policy will undoubtedly be reflected in a corresponding period of prosperity in the history of silviculture in India.

A list of publications received during the year is given below and special attention is drawn to Professor Troup's "Silviculture of Indian Trees." This book marks a very definite and important stage in the history of Indian Silviculture. It is the outcome of several years work in silvicultural research in the Forest Research Institute at Dehra Dun and outlying experimental stations, combined with observations recorded in many parts of India and Burma for a period extending over more than 20 years. The work deals with the trees of India mainly from a silvicultural point of view and takes its place as one of the most important standard works yet published. The author modestly states that it is but an attempt to pave the way for further silvicultural research and now that the importance of such research is becoming more fully realised in India, it is hoped that this work does really indicate the beginning of a rapid advance in the science of silviculture.

FORESTRY

Part II.—Economic Forest Products

BY

W. A. ROBERTSON, I.F.S.,

Forest Economist.

Owing to the new workshops and laboratories for the Economic branch not having been completed, no large developments of research could be undertaken particularly in the Paper Pulp, Seasoning and Minor Forest Products sections.

The balance of the new plant arrived but could not be erected.

A conference of Forest Officers specially concerned with Economic Research was held in January and had a large attendance. A temporary seasoning kiln was erected and various demonstrations were given in the other laboratories.

The Wood Preservation Specialist was not appointed during the year but the appointment is believed to be still under consideration.

Antiseptic Treatment of Timber.—All the experimental sleepers which have now been in the line from 8 to 11 years were inspected and the statistics brought up to date. On August 1st, 1921 Mr. R. S. Pearson, C.I.E., Forest Economist, read a paper at a meeting of the Chief Engineers of Indian Railways in which he explained the objects of these experiments and gave the results to date. At the request of the Railway Board this note was subsequently amplified and handed over to it to publish as a Technical Record for the use of Railway Engineers. A further note on the subject is in the press. It will appear as a Forest Record in continuation of Mr. Pearson's Indian Forest Record, Vol. VI, Part IV. The two methods of treatment which have proved most successful are a mixture of Creosote and Earth Oil introduced in fairly large quantities, and the Powellizing Process, a patent process employing sugar and arsenic. During the year the North-Western Railway have been treating as many Pine sleepers as possible with Creosote in an open tank and have now set up a pressure plant which is about to start work.

Paper Pulp Section.—The machinery and plant for the experimental pulp and paper factory has now arrived and will shortly be erected.

Enquiries continue to be received from parties desirous of exploiting the industry and samples of raw materials forwarded by them and by Forest

Officers have been examined and reported on. The laboratory has also been engaged on an investigation of Bhabar grass with the object of reducing its bleaching cost on the lines which have been successful with bamboo. This promises to yield good results and has reached a stage at which operations can be transferred to the experimental factory as soon as it is erected.

The bamboo survey of the Angul Division, with which this section has been assisting, has been completed.

Substantial progress has been made on the commercial side. A new factory at Naihati, near Calcutta, is now successfully producing paper from bamboo. Another, proposing to use Savannah grass, is in course of erection in Assam.

Seasoning.—(*i*) *Natural*—Final inspections were made by the Officer in Charge of Seasoning, of the natural seasoning experiments in Madras and Coorg. The complete report on all these natural seasoning experiments is in the press.

(*ii*) *Artificial*—A temporary semi-portable kiln was erected in Dehra Dun for demonstration purposes. Both hardwoods and softwoods have been successfully treated.

The special seasoning requirements of the Gun Carriage Factory at Jubbulpore are being studied.

Testing.—About 2,000 routine tests were carried out under Project 1, technically known as "Control tests." For immediate results about 1,000 "Suitability tests" have been made notably for sleeper woods, sucker rods, hammer handles, and wooden plugs for concrete sleepers. In addition to this, tentative grading rules have been drawn up at the request of the Military Works Department for which purpose additional special tests had to be made.

The activities of this section have been most successful, a large amount of information having been made available.

Wood Technology.—Dr. H. P. Brown of Syracuse University arrived to take over charge of the section. A large number of timbers have been identified at the request of forest officers, railway companies and the timber trade generally. Information has been supplied on the suitability of various timbers for special industries.

A start has been made towards preparing general and special keys for the identification of Indian timbers.

Finding of Markets, etc.—As usual a large number of enquiries regarding timber supplied were dealt with and bulletins on the following timbers were issued during the year :—

Odina Wodier.
Bombax malabaricum.
Adina cordifolia.

Gum Resins and Oleoresins and other Minor Produce.—Further areas suited for the tapping of *Boswellia serrata* were considered and a trial

consignment of raw gum sent to England to determine its market value in respect to grade and colour. Further examination of the turpentine is being carried out by the Forest Chemist.

Experiments to improve the yield of the gum of *Sterculia urens* were initiated in several divisions. A large number of enquiries were received dealing with drugs, fixed oils and gums.

Tanstuffs.—On return from leave the Officer in Charge proceeded to Mergui to continue the investigation of the mangroves. During the year he collected the tanstuffs required for the tannage of the exhibits for the British Empire Exhibition.

Charcoal Briquettes.—Briquettes prepared from materials supplied last year were received from America. These together with briquettes made locally were subjected to crushing, rolling and burning tests.

The briquettes were found to be quite well suited to industrial purposes but were not quite satisfactory for domestic use.

ZOOLOGY

I.—GENERAL ZOOLOGY AND PHYSICAL ANTHROPOLOGY

BY

N. ANNANDALE, D.Sc., F.A.S.B.,

Director, Zoological Survey of India.

Tours.—The following tours were undertaken by members of the department:—

	Days.
To Simla from 7th May to 22nd May 1921 by Dr. S. W. Kemp	16
,, Simla from 8th June to 27th June 1921 by Mr. S. L. Hora	20
,, Kashmir from 23rd May to 27th July 1921 by Dr. B. Prashad	66
,, Kashmir from 28th May to 22nd July 1921 by Mr. B. N. Chopra	56
,, Simla from 23rd September to 19th October 1921 by Dr. S. W. Kemp	27
,, Cherrapunji from 24th October to 8th November 1921 by Mr. S. L Hora	16
,, Delhi from 25th November to 4th December 1921 by Dr. S. W. Kemp	10
,, Madras from 27th January to 8th February 1922 by Dr. N. Annandale	13
,, Madras from 25th January to 8th February 1922 by Mr. Srinivasa Rao	15
,, Siju Cave, Garo Hills, from 22nd January to 23rd February 1922 by Dr. S. W. Kemp.	33
,, Siju Cave, Garo Hills, from 22nd January to 23rd February 1922 by Mr. B. N. Chopra	33
,, Southern Shan States from 28th February to 30th March 1922 by Dr. N. Annandale	31
,, Southern Shan States from 28th February to 30th March 1922 by Mr. Srinivasa Rao	31
,, Southern Shan States from 28th February to 31st March 1922 by Mr. S. L. Hora	32
	399

The most important of these tours were those to the Siju Cave, to Kashmir and to the Southern Shan States. From the first of these in particular interesting results are expected. The other two tours were undertaken primarily in connection with the survey of the freshwater molluscs of India and both were successful in attaining the objects for which they were undertaken.

Publications.—The following publications have been issued during the year :—

"Records of the Indian Museum" vol. XXI., part I.

"Records of the Indian Museum" vol. XXII., parts I—V.

"Memoirs of the Indian Museum" vol. V., Nos. 8 and 9.

Library.—Progress has been made in the library, but we have been much handicapped by lack of staff.

The total additions are 2,055 in number. Of these, 728 books and parts of periodicals were purchased and the remainder received in exchange and by presentation.

The following important additions may be specially mentioned :—

(1) Expèdition Antarctique Française. 1903-5. A complete set.

(2) Deuxième Expèdition Antarctique Française 1908-10. A complete set.

(3) The Norwegian North Polar Expedition 1893-96 vols. I-VI. A complete set.

(4) Natura, vols. II-XII : Milan (1911-21).

(5) Feuille de Jeunes Naturalistes. 1872-1913.

All of these except the last were obtained by presentation or exchange.

Collections.—The collections have for the most part remained in good condition but have suffered severely from lack of supervision, due to a numerically inadequate staff both technical and scientific. It has been found impossible to prevent petty thefts of spirit and bottles, which often involved the loss of valuable specimens including a number of "types."

The most important additions to the collections were those made by the members of the department while on tour. The most important received from those not connected with the Museum were a large set of insects, reptiles, etc., collected by Mr. R. P. Mullins in the Chittagong Hill Tracts and presented by him.

Galleries.—The lack of staff and funds have stood in the way of any progress in the public galleries of the Museum. The hope expressed by Dr. Kemp in the last report that a part of the invertebrate gallery would be refitted and opened to the public has not been fulfilled.

In the Ethnological Gallery the additions to the collections were mostly made by the officers of the department and were collected in various parts of India and Burma. A small number were also acquired by purchase, including a set of musical instruments from Baluchistan.

ZOOLOGY

II.—ECONOMIC ZOOLOGY

Part I.—Agricultural Entomology

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S, F.E.S., F.Z.S.,
Imperial Entomologist.

I.—Work at Pusa.

This has followed on the lines of previous years and a more complete account is given in the Annual Report of the Imperial Entomologist.

Work on Borers in sugarcane and other gramineous plants has been continued, Insect Pests have been dealt with as occasion arose. Investigation of life-histories of Indian insects has been continued, their early stages described and figured, the insects reared out including many new to science. A good deal of attention has been paid to an endeavour to ascertain the life-history of *Ochromyia*, but hitherto without success, although it is suspected that the larva lives in the soil and is predaceous, possibly on earth-worms. Further work has been done on the role of blood in ovulation in Culicidæ but no definite results can yet be chronicled. Several cases of human myiasis, due to *Chrysomyia bezziana*, came under notice during the year.

Work with Bees and Lac has been continued and the sericultural experiments were continued until 31st March 1922, when the silk section was transferred to the Department of Industries under the Bihar and Orissa Government.

The usual steady progress has been made, as regards the Insect Survey, with the increase, arrangement and identification of the Pusa collection of insects, which is now a large and important one, and is increasingly taken advantage of by the Provincial Staffs and other workers on Indian Entomology for the identification of their material.

The first part (Acrydidæ) of the Catalogue of Indian Insects was issued during the year and the second and third parts, on Culicidæ and Bombylidæ respectively, were in the press at the close of the year. Active preparation of other parts has been in progress.

Five parts of Entomological Memoirs and the Report of the Fourth Entomological Meeting, containing fifty papers on Indian Entomology, have been issued during the year.

II.—Work in the Provinces.

Madras.—The main lines of research work during the year consisted of :—

(1) Continuation of study of strains of cotton resistant to *Pectinophora affinis*.

(2) *Platyedra gossypiella*. Confirmation of last year's results. Effects of application of the Pest Act, etc.

(3) Bionomics of *Siga inceriellus* and other borers in paddy in the Godavari Delta.

(4) *Hispa* control campaign in South Kanara. A sub-station is now being opened at Kasaragode for the study of this pest.

(5) Study of bacterial infection of cotton bolls and the causes of bud and boll fall. The former with the Government Agricultural Bacteriologist and the latter with the Cotton Specialist.

(6) Preliminary investigation into *Helopeltis theivora*.

Central Provinces.—Observations on the emergence of the *ber* fly (*Carpomyia vesuviana*) were continued last year and the results were written up. In that paper an attempt has been made to correlate the attack of the fruit fly with sweetness of the fruits by quoting results of chemical analysis of the fruits. The Nagpur variety of *ber*, being much sweeter, is attacked more than other wild varieties. The emergence of the fly is shown to have some relation with humidity and temperature. Of the two Braconid parasites of the fly, *Biosteres carpomyiæ* has also a definite æstivation period like that of its host; while *Bracon fletcheri* does not seem to occur when the fruiting season is well advanced. As regards control measures the power of the penetration of the maggots into the soil for pupation, the nature of the soil and æstivation period suggest that the soil underneath the *ber* trees should be disturbed and burnt during the hot weather in order to kill the pupæ.

Bengal.—The following were the chief insect pests under observation during the year: (1) *Rhynchocoris humeralis*, (2) *Cappæa taprobanensis*, (3) *Monohammus versteegi*, (4) *Indarbela tetraonis*, (5) *Rhytidodera simulans*; the life-histories of these pests were worked out and a note was published and distributed amongst the orange growers.

With regard to the Mango Weevil (*Cryptorrhynchus gravis*), the bagging of fruits was continued with success. It has also been found that general failure of a year's crop after the last cyclone of 1919, which meant starving out the weevils, has done a good deal in checking the pest, and so fruits of even the worst-affected trees were almost free from the pest in 1921.

Assam.—Very serious damages were caused by Rice grasshoppers over an extensive area near Hajo in Kamrup where a demonstration in control measures by bagging was conducted.

Cutworms (*Agrotis ypsilon*), which are a regular pest of cold weather crops, cause seriously extensive damage only in cases of commercial growers of onion and potatoes such as those in the South of Habiganj. Two Andres Maire traps were set up near the villages of Khorki and Katora in Bejura Pargana, where about 100 acres of concentrated onion fields were kept under observation from the middle of December to the middle of March last. The idea was to attract the parent moths with molasses, etc., and to trap them before they laid eggs in the fields and so avoid an outbreak of the pests. A large number of moths was captured and the crop suffered no appreciable damage.

Regular classes of Agricultural Inspectors were held and instructions were given to enable those officers to recognize common pests, know their life-history and control measures, to report intelligently on outbreaks and to collect and despatch specimens for identification. Considerable progress has been made with systematic work in this line.

Burma.—*Paddy.*—Investigation of the pests of this crop was carried out at various places. A Conference was held at Sagu (Minbu District) in March with the cultivators in order to inaugurate concerted measures against insect and rat pests in the Mon Canals area.

Seedlings, damaged by *Nymphula depunctalis*, planted separately without any treatment at Hmawbi, were observed to recover and yielded a fair crop.

The damage caused by borer pests, as far as could be observed at different places, was not more than about one per cent. *Chilo simplex* was not met with anywhere. *Siga incertellus* (*Schoenobius bipunctifer*) was, however, observed to injure seriously *Mayin* paddy at Paunglin in the Minbu district. Means of preventing this damage were demonstrated.

Rats were investigated in Leiktho Hills and in the Mon Canals area and a campaign started in the former area with the help of the Deputy Commissioner, Toungoo.

Sugarcane.—Observations were made on the pests. *Holotrichia* grubs were reported as very injurious at Singaing. The life-history of this beetle was traced in the laboratory.

Cotton.—Observations on the bollworm pests were made in the laboratory and in fields.

Chinboung (*Hibiscus cannabinus*) was damaged by *Anomala antiqua* beetles in July and August at Mandalay. Experiments in checking the damage were successful with Kerosine emulsion spray and shaking the plants with a rope in the evening. The life-history of this beetle was traced fully in the laboratory as well as in the fields.

An attack of Aphids on *Pe-Byu-gale* at Mandalay and Tatkon was successfully checked with simple soap solution.

Brachytrypes portentosus (*Payit*) was investigated at Madaya.

Palms.—*Oryctes rhinoceros* was fully studied both in different districts and in the laboratory throughout the year. A paper was prepared and will be printed and distributed soon.

The red weevil (*Rhynchophorus ferrugineus*) also was under observation. An attack on coconut by *Nephantis serinopa* at Mandalay was checked by cutting off and burning the affected lower leaves.

Tea.—Zeuzerid and Arbelid pests were reported from Thaungdut and proper remedies were suggested.

Silk.—Work in the Maymyo nursery was started in October and microscopically-examined eggs have since been regularly supplied to the rearers in Prome. A full demonstration of rearing, reeling, etc., was given in the exhibition held in connection with the Biennial Co-operative and Agricultural Conference held in August 1921 at Mandalay.

Lac.—Arrangements were made for growing the proper variety of *Cajanus indicus* (*pe-sinn-gon*) at Maymyo, Mandalay, Padu, Tatkon, Hmawbi, Allanmyo and Pwinbyu for trying lac.

Bees.—A start was made with four colonies of *Apis indica* at Maymyo.

Bihar and Orissa.—The work on the parasite of *Agrotis ypsilon* was continued. It has been seen as in the previous year that for a successful rearing of the host a cooler temperature than that prevailing in the Plains in August and September is necessary.

Observations were made on the life-histories of a large number of major and minor pests and the life-histories of some pests have been and are being worked out in the Insectary.

Eggs of Eri silkworms were supplied to the Department of Agriculture, U.S.A., at the request of their Agricultural Explorer.

United Provinces.—Research work in the United Provinces was almost entirely confined to pests of cotton, and centred largely upon the pink bollworm, *P. gossypiella*, Saund. and the spotted bollworms, *E.fabia*, Stoll., *E. insulana*, Boisd., and *E.cupreoviridis*, Wlk., as being the most important economically. An extensive investigation of these insects was carried on throughout the whole year both in the field and laboratory, from biological and statistical standpoints. Particular attention was given to the variation in length of life-cycle, and rate of increase, and to hibernation; and, in the case of *P. gossypiella*, to the assumption of the "long cycle" habit, and dates of subsequent emergence of moths. Considerable *data* were collected upon the percentage of infection and consequent loss of crop. The work must be regarded as preliminary only to a fuller investigation, and its main object was to indicate the lines of future research. Experimental sowings of heat-treated seed were made for the ensuing season. Investigations were also conducted on the mothborers of *juar*, *Idiocerus* spp., and *Monophlebus* sp., on mango, and *Galerucella singhara*, Lef., on water-nut (*Trapa bispinosa*).

Punjab.—Cotton Bollworm was not a serious pest in this Province last year. The percentage of attack was about five to seven per cent.

Figures of the percentage of parasitization of the bollworms have been collected from the different parts of the Punjab. At Hissar as many as fifty per cent. of the bollworms were found parasitized by *Microbracon lefroyi* and *Rhogas testaceus*.

Experiments were started on various lines to control the stem-borers of maize and sugarcane. Light traps (50 candle power) were set up to attract the moths. This was done for a fortnight, two hours every day. In all 499 *Chilo* sp. (51 males and 448 females), 84 *Scirpophaga* (17 males and 38 females), 69 *Polyocha* (17 males and 35 females), were trapped.

Euphalerus citri, a Psyllid pest of *Citrus* trees, was successfully controlled by means of spraying at several places. The attack of *Dialeurodes citri* (*Citrus* Aleyrodid) was noticed for the first time last year. Sprayings were tried against this pest also, but the percentage of mortality was not so high as in the case of the Psyllid.

Winter sprayings against the mango hoppers (*Idiocerus atkinsoni* and *I. clypealis*) were again done during the last year. The hoppers were considerably reduced in numbers in the treated gardens.

With regard to pests of stored grains, confirmation has been obtained of Prof. Dendy's results on air-tight storage; about sixty experiments were performed and in all the completely air-tight vessels the larvæ of the *Khapra* beetle died within a few days. Even very badly infested wheat, when kept under air-tight conditions, improved in so far that all the stages of insects attacking it, were killed.

A long series of experiments on superheating of the infested grain was also performed and superheating was successfully employed in killing the larvæ in several seed godowns. When treating godowns empty of grain, but infested with the pest, desiccation is cheaper and is as successful as fumigation with carbon bisulphide or hydrocyanic acid gas.

Laying of the poisoned baits (Strychnine and arsenious acid) and fumigation with carbon bisulphide by means of the Suddeath Rabbit Exterminator have proved very useful in killing rats.

III.—Native States.

Mysore.—The most important result obtained during the year is the discovery of a very simple method of controlling sugarcane borer (*Diatræa* sp.). The method consists in trapping the moths in small trash heaps appropriately placed in the cane field. Trials have shown that damage can be reduced from forty to two per cent.

The usual campaign against the *Kamblihulla* pest (*Amsacta albistriga*), conducted in 23 villages, resulted in the capture and destruction of 1,20,000 moths representing six million caterpillars. The control of the Castor Semilooper pest (*Achæa janata*) was successfully carried out in six villages and demonstrated in twenty others.

From results obtained with Brunolineum as a wash against *Xylotrechus quadripes* it appears that chemicals going by that name are not all identical in composition.

Other investigations related to the Rhinoceros beetle, mango hoppers, Lime tree borer, Paddy stem borer, a new beetle pest of cane, *Epilachna* on potato, Bruchids, and Tobacco Aphid.

Travancore.—The swarming caterpillar (*Spodoptera mauritia*) caused considerable damage to the *punja* rice crop in Kuttanad. The attack of rice stem borer (*Siga incertellus*) was very severe on the rice crop in South Travancore; observations were made under field conditions of the habits and life-history of the pest. The rice leaf roller (*Cnaphalocrocis medinalis*) is another serious pest which appeared in several places during the year; beating the crop with a stout cane held in a horizontal position and sprinkling a mixture of wood ashes and lime in the proportion of 4 : 1 was tried with great success. An attempt was made to study the life of the rice bug (*Leptocorisa varicornis*) after the harvest of the rice crop; the remedy suggested in " The short notes on insect pests of crops in Travancore " was found more effective than any other. Other minor pests of rice dealt with during the year were the rice *Hispa*, rice case-worm and rice skipper.

Of the pests of the coconut palm, *Nephantis serinopa*, owing to its expansion throughout the sea-board taluqs and the highly destructive nature of its attack, was by far the most important pest that engaged the attention of the Department during the year. Rules have been framed under the Plant Pest Regulation to enable the officers of the Department to adopt prompt measures to eradicate this pest. Temporary fieldmen were engaged in several places to bring the pest under control. Despite all these efforts the attack of the pest still continues.

Baroda.—The main work done during the year was demonstration of control measures against grasshoppers.

ZOOLOGY

II.—ECONOMIC ZOOLOGY

Part II.—Forest Entomology

BY

N. C. CHATTERJEE, B.Sc., F.E.S.,

Assistant to Forest Entomologist.

The office of the Forest Zoologist (Entomologist) was held by Mr. C. F. C. Beeson, M.A., I.F.S., F.E.S., up to the 15th May 1922. From the 16th May to present date Mr. W. F. Perree, C.I.E., President, Forest Research Institute and College, held charge of the office.

Insects of Sal.—Borers (*a*) *Field Work.*—In Thano Forests, Dehra Dun, an area of epidemic occurrence of *Hoplocerambyx spinicornis*, enumerations were made to obtain comparison of the annual attack as affected by climatic conditions and control measures. During the season 1921, the number of trees attacked was estimated at 6,000 which was 24% of the attack in the heaviest year when the rainfall was 117 inches being 34 inches above normal. The rise in the total annual rainfall has resulted in an increased mortality of the attacked trees as was expected ; but the actual number of deaths in 1921 in the seven compartments used as sample plots was 30 % of the number in 1917, a year with approximately the same rainfall. This reduction is considered to be due to the control measures formulated in 1920. Under all conditions of rainfall, the distribution of attack was found to be uniform throughout the girth classes.

(*b*) Experiments on the correlation of rainfall and periodic emergence of *Hoplocerambyx spinicornis* were repeated in the Insectary and previous results were confirmed. The survival and successful emergence of the borer in sleepers, beams, rafters, slabs, etc., was demonstrated.

(*c*) The length of life, fecundity, oviposition, incubation of beetles and early development of the larvæ were studied under variable conditions of humidity in the laboratory. Dry conditions were found to be unfavourable in all cases and fatal below 60% relative humidity. Extreme wet conditions were found to be less favourable. The limits of the optimum conditions have not yet been determined.

(*d*) Further informations have been collected on the life-histories of other borers in particular of *Xylotrechus smei* and *Sphærotrypes siwalikensis*. The genus *Sphærotrypes* is being revised in connection with the biology of *Sphærotrypes siwalikensis* and preliminary conclusions have been published by Mr. Beeson in the Indian Forester.

Insects of Teak.—(*a*) *Beehole borer.*—A preliminary note on the ecology and economic status of the beehole borer, *Duomitus ceramicus*, by Mr. Beeson was published during the year.

(*b*) *Other pests.*—A compilation of the available information on teak pests has been started, but completion of the work is postponed until Divisional Forest Entomologists are available for further research.

(*c*) Examinations of the possible host trees of a sister-species of the beehole borer *Duomitus leuconotus*, are being carried out in the Dehra Dun forests with a view to study the biology and life-history of the genus *Duomitus*.

Miscellaneous Pests.—The shothole borers of the evergreen forests.

A tour in May and June 1921, in Sibsagar and Lakhimpur Divisions, Assam, indicated that the dominant feature of the borer fauna of felled timber, is the numerical superiority of the shothole borers *Platypodidæ* and *Xyleborinæ* which are rich in species of Malayan forms new to India. In the evergreen forests trees like *Vatica lanceæfolia*, and *Dipterocarpus pilosus* are attacked in addition to the local series by almost all the shothole borers occurring in *Shorea robusta* in Bengal and North West Assam. Passing into the drier Dipterocarp forests with fewer tree species in admixture, the shothole borer fauna grows sparse and species like *Diapus furtivus* and *Platypus solidus*, which in the moist evergreens are less abundant, become the dominant members of the association.

THE BORERS OF TIMBER UNDER SEASONING.—

Work was continued on the liability to attack, by borers, of timber under different methods of seasoning, and on the species of insects responsible for the various forms of damage. A summary of the results has been prepared for the press in collaboration with the Timber Seasoning Officer.

A general survey made of dead trees, on the variety and extent of borer injury, yielded the unexpected information that the living tree is commonly subject to attack by insects of the beehole borer type, which damage the timber without seriously affecting the vitality of the tree. Recognition of this type of damage permits a correct appreciation of value of empirical methods of seasoning.

Insect pests of Afforestation.—Field work in September 1921, in Afforestation Division, U.P., indicated that plantations of *Acacia arabica*, *Dalbergia Sissoo*, etc., are not subject to serious damage by insects, except under epidemic conditions.

Borer of Museum exhibits.—The biology and life-history of a polyphagous species, *Stromatium barbatum*, *Fabr.*, a serious pest of stored timber polished and unpolished museum wood specimens, etc., is under study.

Parasites of Scale-insects and wood borers.—Dr. Waterston's paper describing new species of *Chalcidoidea* parasites on pests of Chir, Sal, Toon, Sundri, etc., is in the press as a Forest Record.

Miscellaneous pests.—A total of 131 consignments including 311 wood specimens, and many shoots and cones, etc., were received for investigation during the year under report. From these some 11,000 insect specimens belonging to various orders have been bred out, which have added considerably to our knowledge of host plants and distribution of forest pests.

SYSTEMATIC ENTOMOLOGY

BY

DR. M. CAMERON, M.B., M.R.C.S., L.R.C.P., R.N.,

Systematic Entomologist.

Work in this section has been continued on the identification of material in the Institute and its incorporation in the collections as under :—

	Specimens.
Lepidoptera	1,640
Rhynchota	1,568
Coleoptera	856
Hymenoptera	709
Neuroptera Odonata	319
Orthoptera	146
Diptera	123
Other orders	50
TOTAL	5,411

The number of species added is 636 of which 30 are either types or co-types.

Numerous parcels of insects received from Forest Officers have been determined and their habits noted.

The number of insects set during the year under consideration is 15,800.

VETERINARY SCIENCE

BY

J. T. EDWARDS,

Director, Imperial Bacteriological (Veterinary) Laboratory, Muktesar.

For the greater part of the year the higher technical staff was limited to the officiating director, third bacteriologist, veterinary officer, and hence the researches of the laboratory were restricted in view of the contingent demands of routine serum manufacture and administration.

Rinderpest.—The investigations foreshadowed in last year's report were carried out. Experiments showed that it is possible to utilise animals of moderate susceptibility to rinderpest, namely, buffaloes, as virus producers in the process of hyper-immunising animals for routine serum preparation. Carefully controlled tests indicated that inoculation with a single protective dose of anti-rinderpest can be depended upon to confer a passive immunity upon susceptible animals for nine days, after which interval the protection needs to be repeated in the scene of persisting massive infection. Increased doses of serum confer an immunity of perceptibly longer duration, which however, appears to be far short of being in direct proportion to the increase in dosage.

The immediate and lasting benefits that would accrue from widespread active immunisation, by the simultaneous or serum-virus method, are demonstrated in the laboratory publications; the administration of a large protective dose of serum in this method with the object of diminishing the severity of the reaction due to the virus-injection did not seem to inhibit the production of the desired degree of active immunity. A type of apparatus was devised which had for its object the easy and efficacious hyper-immunisation of animals on a large scale with virulent blood.

Contagious Abortion in Equines.—Experiments were carried out in order to determine the infectivity of strains of *Bacillus abortivo-equinus*, isolated from the outbreaks on the Hissar Cattle Farm, upon pregnant pony and donkey mares. Attempts were commenced to control this disease by the systematic application of serological tests.

Hæmorrhagic Septicæmia.—Methods of estimating the efficacy of the serum issued for the protection of cattle against this disease were tested.

Mange.—Some preliminary work in laboratory methods of testing the commonly used acaricides of the country was undertaken.

Black quarter.—Material is being collected with a view to making a systematic study of the strains of micro-organisms responsible for this condition in India.

II.—Camel Specialist, Sohawa, Punjab.

The work carried out by this officer is covered in the following summary :—

(*a*) A simple, inexpensive and practical method of treating surra in camels (*viz.*, by tartar emetic) has been found. Camels treated here have been inspected by officers of the Royal Army Veterinary Corps before they have been returned to military duty.

(*b*) Surra transmission experiments.

Transmission experiments were carried out during the year with :

1. *Tabanus nemocallosus.*

2. A new species of Ornithodorus.

A. From these experiments it would appear that the spread of surra by Tabanidæ is by direct transmission and that there is no cycle of the trypanosome in the fly, whereas by the new species of tick, transmission is not direct, but there is probably a cycle of the trypanosome within the tick.

The transmission of surra by Tabanidæ would appear to depend upon :—

(*a*) The number of trypanosomes per field in the blood of the surra infected animal at the time the flies are feeding.

(*b*) The interval of time between the interrupted surra feed and the feed on the healthy animal.

(*c*) The number of flies that are interrupted in their feed on the surra infected animal and proceed to finish their feed on a healthy animal.

B. The new species of Ornithodorus was found capable of transmitting surra to healthy rabbits 67, 83 and 101 days after feeding on a surra infected animal, but was not infective after intervals of 1 minute to 46 days.

3. The course that camel surra runs in other animals. Further experiments were carried out; from these experiments it was ascertained that the blood of buffaloes, sheep and goats remains infective for many months, though these animals may appear in perfect health and no trypanosomes can be found in the blood.

4. Collections of flies, etc., have been made in many areas.

The following species were found :—

(1) Hypoderma of goats.

Major Patton examined this fly and has named it *Hypoderma crossii.*

(2). Species of Ornithodorus.

Specimens of this tick were sent to Professor Brumpt of the Paris University, who states it is a new species and proposes to name it *Ornithodorus crossii.*

(3) *Tabanus suflis* (Jaenæke).

Major Patton identified this fly ; he stated that as far as he was aware this species has not been reported before from India.

(4) *Lipoptina caprina* (Austen).

This hippoboscid was identified by Major Austen of the British Museum; he stated that up till then the hippoboscid had only been found in Palestine.

(5) Bot flies.

Bot flies and their larvæ, of camel, sheep, goat, horse and oorial have been collected.

III.—Superintendent, Government Cattle Farm, Hissar, Punjab.

The following subjects were treated during the year under report:—

(*a*) Feeding experiments at the Government Cattle Farm, Hissar, by Mr. R. Branford and Captain E. Sewell.

(*b*) Contagious orchitis in donkey colts, by Mr. R. Branford and Captain E. Sewell.

(*c*) An experiment in breeding varieties of oats along Mendelian lines, by Mr. R. Branford and Captain E. Sewell.

(*d*) Experiments in *Bir* cultivation, by Mr. R. Branford.

(*e*) Anthrax at Hissar, by Mr. R. Branford.

(*f*) Cattle stock and Fodder Famine, by Mr. R. Branford.

(*g*) The importance of the genus Habronema as an economic factor amongst the equidæ of Punjab and North-West Frontier Province, by Captain E. Sewell.

(*h*) Contagious abortion in pony and donkey mares (still in progress), by Mr. R. Branford and T. M. Doyle.

IV.—Madras Presidency.

Contributions of local professional interest were made by members of the Provincial Veterinary Service in the "The Madras Veterinary Journal," now the only veterinary periodical in India. Five numbers appeared during the year. Of special interest are short articles on (1) Infective nasal granuloma or "snoring disease" of cattle, (2) the treatment of ankylostomiasis in dogs, and (3) epizootic ulcerative keratitis of cattle.

MEDICAL RESEARCH

BY

The Hon'ble Major-General Sir WILLIAM RICE EDWARDS, K.C.I.E., C.B., C.M.G., M.D., F.R.C.S.E., K.H.P., I.M.S.,

Director-General, Indian Medical Service.

The following is an extract from the Annual Report of the Scientific Advisory Board of the Indian Research Fund Association for the year 1921-22 :—

Relapsing fever.—Major Cragg submitted a final report on the results of his inquiry. This has been published in the Indian Journal of Medical Research, Vol. X, No. 1, July 1922 (Relapsing Fever in the United Provinces of Agra and Oudh). The paper is a long and valuable one.

Plague and Rat-fleas.—Along with his inquiry on the Relapsing Fever, Major Cragg made investigations on the Indian rat-fleas and the results were published in the Indian Journal of Medical Research, Vol. IX, No. 2, October 1921 (The geographical distribution of Indian rat-fleas as a factor in the epidemiology of plague). Major Cragg examined 17,339 rat-fleas from the Punjab, Bombay, Central India, Madras and Burma.

Leprosy.—(1) Dr. Muir continued to study the effects of the derivatives of the chaulmoogra oil in the treatment of leprosy on modern lines. He has carried out serological studies in connection with leprosy, and, in collaboration with Major R. B. Lloyd, I.M.S., is studying the Wassermann re-action in cases. He is carrying out histological examination of leprous nodules and skin at different stages.

(2) Dr. Sudhamoy Ghosh continued his researches on leprosy under the supervision of Lieutenant-Colonel J. W. D. Megaw, I.M.S., up to 15th December 1921. On the 1st March 1922 Mr. Nishi Kanta De was appointed in his place. He is investigating the bactericidal properties of various oils and fatty acids in the destruction of acid-fast bacilli.

(3) Grant to the Rev. Frank Oldrieve. In October 1918 a sum of Rs. 21,650 was allotted for the medical treatment of lepers and training of Sub-assistant Surgeons. In this inquiry trial treatment on modern lines have been carried out at various Leper Asylums. Dr. Muir, who is supervising the work during the absence of Mr. Oldrieve in England, writes, " that the death rate at Purulia Leper Asylum has been reduced by almost 25 per cent. since special treatment and hookworm treatment began."

(4) Inquiry on Nim or Margosa oil and its derivatives. Dr. K. K. Chatterjee continued his experiments with the products of nim oil in the treatment of malignant disease during the year under report.

Influenza.—(1) A selected Sub-assistant Surgeon was employed on the termination of Major King's inquiry to collect statistics regarding the efficiency of the new influenza vaccine. Statistical figures from different parts of India have been received. On return from leave, Major King may take up this question.

(2) Captain R. H. Malone concluded his bacteriological inquiry on 4th December 1920. The following articles by him were published in the Indian Journal of Medical Research :—

(*a*) The production of B influenza vaccine on a large scale. Vol. IX, No. 1, July 1921.

(*b*) A bacteriological investigation of influenza carried out under the Indian Research Fund Association, Part II. Influenza in Bombay, July 1919 to June 1920. *Ibid.*

Pneumonia Inquiry.—Captain R. H. Malone conducted this inquiry throughout the whole year under review. " A note on the large scale production of Pneumococcus Vaccine " by him was published in the Indian Journal of Medical Research, Vol. IX, No. 1, July 1921. Captain Malone during the year carried out trials with an anti-pneumococcic vaccine in the Waziristan Force.

Deficiency Diseases Inquiry.—Lieutenant-Colonel R. McCarrison was deputed by the Indian Research Fund Association to work at Oxford from the 29th January 1921. He worked there under Professor Sherrington, P.R.S. He delivered a course of lectures on deficiency diseases in America. During 1921 he published a book entitled " Studies in deficiency diseases." A paper on " Pathogenesis of deficiency disease, Part XI," has been received and is in course of publication in the Indian Journal of Medical Research.

Indian Mosquitoes Inquiry.—Captain P. J. Barraud is conducting this inquiry which will terminate on the 25th February 1924. An important paper by Mr. F. W. Edwards, the British Museum, entitled " A synopsis of adult oriental culicine (including megarhinine and Sabethine) mosquitoes " was published in the Indian Journal of Medical Research, Vol. X, No. 1, July 1922. This paper will form an introduction to the articles which Captain Barraud will publish on his researches in India.

Kala-azar Inquiry.—(1) Mrs. Adie resigned on account of ill-health on the 3rd January 1922. Lieutenant-Colonel Mackie proceeded on leave to England on the 31st January 1922 and Major Shortt took over the work from him. Mr. Awati was transferred to the Education Department as Professor of Zoology in the Institute of Science, Bombay, on 1st June 1922. The following papers dealing with this inquiry have been published in the Indian Journal of Medical Research :—

(*a*) A preliminary note on the development of Leishman-Donovan Parasite in spleen juice and in the Alimentary tract of cimex Lectularius, by Mrs. Adie, Vol. IX, No. 2, October 1921.

(*b*) A note on bodies observed in Cimex Rotundatus Linne collected in a kala-azar infected area in Assam, by Mrs. Adie, Vol. X, No. 1, 1922.

(*c*) Some notes on Conorhinus Rubrofasciatus (de Geer), by Mr. Awati, Vol. IX, No. 2, October 1921.

(*d*) Survey of biting insects in Assam with reference to kala-azar for the whole year from November 1921 to October 1922, by Mr. Awati, Vol. X, No. 2, 1922.

(2) Dr. U. N. Brahmachari's inquiry is associated with the investigations on kala-azar. He has been engaged during the year in carrying out researches on organic preparations of antimony at Calcutta for the treatment of kala-azar. His results to date were published in the Indian Journal of Medical Research. "Chemotherapy of Antimonial compounds in kala-azar infection, Part I," Vol. X, No. 2, October 1922.

Ankylostomiasis Inquiry.—Dr. Mhaskar in co-operation with Dr. Kendrick of the Rockefeller Foundation carried out, under the auspices of the Indian Research Fund Association, an anti-hookworm campaign in the Tea Estates of Mudis, Coimbatore District, and (2) Kalianapandal. The campaign was followed by a marked improvement in the health of the coolies working on the estates. The results of Dr. Mhaskar's and Father Caius's inquiries have been published in the Indian Journal of Medical Research in :—

Vol. VIII, No. 1, 1920.
Vol. VIII, No. 2, 1920.
Vol. IX, No. 1, 1921.
Vol. IX, No. 2, 1921.
Vol. IX, No. 4, 1922.
Vol. X, No. 2, 1922....

Immunology with special reference to Antivenin.—This inquiry was commenced in June 1921 by Father Caius. The main object of his investigations on the Antivenin is to concentrate the serum now prepared at Kasauli, the idea being to obtain greater potency for less bulk, thus enabling larger doses to be more easily given and also obviating to some extent the possibility of serum sickness. He is attacking this problem both by physical and chemical methods. Some of the physical methods depend on evaporation, others on dialysis and others on electrolysis.

Analysis of quinine and cinchona Derivatives.—Father Caius is also conducting an inquiry on this subject. He is co-operating with Major Sinton and is conducting the chemical analysis of quinine, etc., for him. He visited the Government quinine factories in Madras and Bengal.

Anthelmintic Properties of Drugs.—Father Caius continues to carry out researches on Anthelmintic Properties of Drugs.

Quinine and Malaria.—Major Sinton, V.C., O.B.E., I.M.S., conducted this inquiry throughout the whole year. He has elaborated and simplified a method for the cultivation of the malarial parasite. He is at present engaged in elaborating and testing a method of treatment of malaria in which alaklies

are combined with quinine. The following papers have been published in the Indian Journal of Medical Research in connection with this inquiry :—

(*a*) A simplified method for the cultivation of Plasmodium Falciparum in vitro, Vol. X, No. 1, 1922.

(*b*) Further remarks on a clinical method for the cultivation of sub-tertian parasite in vitro, *Ibid.*

(*c*) A case of malaria due to Plasmodium tenue (Stephens), Vol. X, No. 2, July 1922.

(*d*) A possible fallacy in the 'thick film' method of examination for malarial parasites, Vol. X, No. 2, October 1922.

Research on Cinchona Alkaloids.—This research was commenced at the Calcutta School of Tropical Medicine and Hygiene by Major H. W. Acton on the 4th January 1922. A paper dealing with this research has been published in the Indian Journal of Medical Research entitled "on the Behaviour of Paramecium Caudatum towards the Cinchona Alkaloids," Vol. IX, No. 2, October 1921. Other papers on quinine prophylaxis and treatment of malaria have been published by Major Acton and his colleagues in the Journal.

Composition of River Waters.—This research on the seasonal variations in the composition of the river waters in Bengal and influence which these variations exert on the processes of sedimentation and filtration of water is being conducted by Rao Sahib V. Govinda Raju.

Lathyrism.—The chemical aspect of this investigation is being carried out by Dr. J. L. Simonsen, the botanical aspect by Mr. Howard, and the pharmacological part by Captain Anderson, I.M.S. The inquiry commenced in December 1921 and will last for three years. The results of this inquiry so far have been interesting and suggestive.

Ground-nuts and Sterilisation of water supplies by chlorogens.—Dr. McKenzie Wallis, who is continuing his researches in England, has not yet submitted his report.

Cercariæ Indicæ.—The results of Major Sewell's investigation are incorporated in an important monograph which has been published by the Indian Research Fund Association as a supplementary number Vol. X, June 1922 of the Indian Journal of Medical Research. This work is a most important addition to our knowledge of this subject and will form the basis of future investigations connected with Bilharzial infection.

Entomological section of the Central Research Institute, Kasauli.—The Governing Body of the Indian Research Fund Association met the expenses of this section for the year under report.

Training of Sub-assistant Surgeons and Laboratory attendants.—This scheme will furnish officers in charge of inquiries with trained subordinate personnel immediately. One Sub-assistant Surgeon and two laboratory attendants are being trained at four Institutes.

Indian Journal of Medical Research.—The Indian Journal of Medical Research has just completed its ninth year of existence.

INDEX.

A

	PAGE.
Afforestation, experiments on	50
,, insect pests of, work on	65
Air, upper, investigations of	10
Animal nutrition, initiation of, work on	5
Ankylostomiasis inquiry	73
Antiseptic treatment of timber	53

B

Bacteriology, agricultural, work of year	48
Barley, economic botany of, work on	36
Ber, insect pests of, work on	59
Black quarter, work on	68
Borers of timber under seasoning, work on	65
Botanical Survey	29
Botany, economic, agricultural	33
Botany, economic, cinchona cultivation in Burma	31
,, systematic, in various provinces, work on	29

C

Camels, veterinary work concerning	69
Carcariæ indicæ, results of, work on	74
Cereal diseases, work on at Pusa	43
Charcoal briquettes, testing of	55
Contagious abortion in equines	68
Cotton, economic botany of, reference to work of year on	34
,, insect pests of, work on, in United Provinces	61
Cutworms, trapping of moths of	60

D

Deficiency Diseases inquiry	72

E

	Page.
Economic enquiries, geological	15
Entomology, agricultural, work concerned with in various provinces	58
Entomology, forest	64
,, systematic, work concerning	60
Essential oils of various Indian species, work on	6

F

Fixed oils, work on	6
Flora of Madras Presidency, reference to	30
Fodder crops of Western India, information concerning	36
Forecasting meteorological, daily and seasonal	10
Forest Flora	41
Forestry, Economic Forest products	53
,, silviculture	49
Fungoid attacks on trees, possible extension of	42

G

Geodesy	16
Geodetic publications	26
Geology	14
Grapes in Western India, increasing yield of	37
Gum resins and Oleoresins, work on	54

H

Hæmorrhagic Septicæmia, work on	68
Hyacinth, water, economic botany of, work on	35

I

Immunology with special reference to antivenin	73
Indian Mosquitoes inquiry	72
Indigo, bacteriological work concerning	48
Influenza, work concerning	72
Ipecacuanha in Burma, cultivation of	32

J

Jute, economic botany of, work on	36
,, influence of manure to, for limiting incidence of disease	45

K

PAGE.

Kala-azar inquiry 72

L

Lac, Japanese and Burmese, chemical study of 7
Lathyrism investigations concerning, in hand 74
Latitudes, astronomical, work on 28
Leprosy, work concerning 71
Levelling operations, in various provinces 24

M

Magnetic observations 12
„ Survey 12
„ survey observations at Repeat Stations 12
„ survey, special observations during total eclipse 13
Malaria, work concerning 73
Mange, work on 68
Mango, insect pest of, work on 59
Manures, effect of, on tea, sugarcane, etc. 4
„ organic, work on 4
„ phosphatic, work on 4
Medical Research 71
Megasse as source of pulp and alcohol 7
Millet, diseases of, control of 44
Mineralogy 14
Mount Everest expeditions, note on 28
Mycological work in various provinces 45

O

Oil seeds, castor and safflower, work on 36
Opium, work on and results 5

P

Palæontological work in progress 14
Palms, production of improved jaggery from 4
Paper pulp, industry, development of 53
Piricularia, species of, causing disease 43

PAGE

Plague, work concerning 71
Pneumonia inquiry 72
Publications, Botanical Survey 32
Forest Entomology 66

R

Relapsing fever, reference to, results of, enquiry on 71
Rice, diseases of, work on 44
„ economic botany of, work on 36
„ insect pests of, work on in Travancore 63
Rinderpest, work in hand on 68
River waters, composition of, work on 74

S

Sal, insect pests of, work on 64
Sal, œcology of, work on 38
Sandal, pathology of 41
Seasoning of timber, experimental work on 54
Silvicultural systems, development in 52
Silviculture, experimental, work on 51
„ in India, development of, study of 52
„ statistical work 49
Soils, chemical survey of 3
Soil nitrogen, work on 3
Soils, saline, reclamation of 3
Solar physics 8
Spectroscopic research 8
Spirit levelling, in India, history of 19
Stratigraphy 14
Sub-assistant Surgeons, training of 74
Sugar cane, economic botany of, reference to work of year on 35
„ insect pests of, work on 58
„ in the U. P. experiments with 4
„ work on, diseases of 45
Suitability tests with timber 54
Surveys, geological, in provinces 14
„ gravimetric, in India, history of 21
Systematic forest botany 40

T

Tanstuffs, collection of and work on 55
Teak, insect pests of, work on 65

PAGE.

Tea, tannin content of, work on 5
Tidal operations 23
Timber markets, finding of 54
Triangulation, Indian, history of 16

V

Veterinary Science 68

W

Wheat, economy botany, reference to work of year on 34
Wood technology 54

Z

Zoological Survey, collections 57
" " departmental tours 56
" " galleries, condition of 57
" " library work 57
" " publications of the year 56
Zoology 56

Departmental Publications.

I.—Meteorological Department—

Government of India Office.

(1) The Indian Daily Weather Report and Chart.
(2) The Weekly Rainfall Summary.
(3) The Monthly Weather Review.
(4) The Annual Summary.
(5) The Rainfall of India.
(6) Indian Meteorological Memoirs.

Bengal Office.

(1) Bengal Daily Weather Report and Chart.
(2) Monthly Rainfall Tables and Summaries of the chief feature of the weather of the month over Bengal.

Bombay Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

Madras Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly Rainfall Tables (*Madras Gazette*).

Allahabad Office.

(1) Monthly Weather Summaries (*United Provinces Gazette*).
(2) Annual Summary.
(3) Monthly Rainfall Tables (*United Provinces Gazette*).

Lahore (Simla) Office.

(1) Monthly Summary } of Punjab weather.
(2) Annual Summary }

II.—Geological Survey.

The publications of the Department include—

Palæontologia Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XLV, including the larger papers on geological subjects.

Records, Vols. I—L, including the shorter papers and Annual Reports from 1868 to 1915 sold in parts, priced one rupee each.

Manual, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta.

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Board of Scientific Advice for India

ANNUAL REPORT

FOR THE YEAR

1922-23

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1924

Price Re. 1.

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CONTENTS.

		PAGE.
I.—Annual Report—		
APPLIED CHEMISTRY—		
I.—*Agricultural*	W. H. Harrison, D.Sc.	1
II.—*Forest*	J. L. Simonsen, Ph.D.	6
ASTRONOMY	J. H. Field	8
METEOROLOGY		
TERRESTRIAL MAGNETISM		
GEOLOGY	E. H. Pascoe, Sc.D., M.A., D.Sc., F.G.S., F.A.S.B.	14
GEODESY	Lieutenant-Colonel H. McC. Cowie, R.E.	16
BOTANY—		
I.—*Botanical Survey*	C. C. Calder, B.Sc., B.Sc.(Agri.), F.L.S.	19
II.—*Economic Botany*—		
I.—*Agricultural*	A. Howard, C.I.E., M.A., A.R.C.S., F.L.S.	25
II.—*Forest*	R. N. Parker, F.C.H.	29
III.—*Mycology*	W. McRae, M.A., B.Sc., F.L.S.	31
AGRICULTURAL BACTERIOLOGY	C. M. Hutchinson, B.A., C.I.E.	36
FORESTRY—		
I.—*Silviculture*	S. H. Howard, B.A.	42
II.—*Economic Forest Products*	R. S. Pearson, C.I.E.	45
ZOOLOGY—		
I.—*General Zoology and Physical Anthropology*	N. Annandale, C.I.E., D.Sc., F.A.S.B.	51
II.—*Economic Entomology*—		
I.—*Agricultural*	T. B. Fletcher, R.N., F.L.S., F.E.S., F.Z.S.	53
II.—*Forest*	C. F. C. Beeson, D.Sc., F.E.S., I.F.S.	59
VETERINARY SCIENCE	J. T. Edwards. B.Sc., M.R.C.V.S.	63
MEDICAL RESEARCH	The Hon'ble Major-General R. Charles MacWatt, C.I.E., M.B., F.R.C.S., K.H.S., I.M.S.	68

Annual Report of the Board of Scientific Advice for India 1922-23.

APPLIED CHEMISTRY

PART I.—AGRICULTURAL CHEMISTRY

BY

W. H. HARRISON, D.Sc.,

Imperial Agricultural Chemist.

SOILS.

Methods of Analysis.—The Agricultural Chemist to the Government of the Central Provinces has made a study of the various methods used for the mechanical analysis of soils with a view to select a method suitable for general adoption in India. In order to obtain wide variations in the character of the soil used for comparison typical samples were obtained from the other Provinces.

Soil Surveys.—The Soil survey of the South Bhagalpur has been completed by the officers of the Bihar and Orissa Government and an extension of his work has been made through South Monghyr across the basin between the Kharagpur and Barabar Hills.

The Officers of the Indian Tea Association have continued the survey of the Tea Districts and notes dealing with the Mangaldai and Tezpur Districts have been published.

Soil Nitrogen.—Clarke has published his important observations on the nitrate fluctuation in the Gangetic alluvium of the United Provinces whilst at Pusa the study of the movements of nitrate in the subsoil to a depth of nine feet has been continued. The latter investigation has directed attention to the large loss of nitrogen which can occur when green or organic manures are applied during a heavy monsoon.

This problem has also been taken up by the Officer of the Indian Tea Association and a study of the nitrogen recuperation in the soils of the Deccan has been undertaken by the Agricultural Chemist to the Government of Bombay.

Saline and Acid Soils.—Meggett has published his second paper dealing with observations made on an acid soil of Assam in which he has investigated the nitrogen losses from such soils during periods of heavy rain-fall. The

134336

question of soil acidity is of peculiar interest to tea producers and the Officers of the Indian Tea Association are making a detailed study of subject both in the field and laboratory. It is expected that the information obtained hitherto will be published shortly.

In the Punjab Lander has continued his experiments with the "Bara" soils of the Montgomery Districts. From investigations made on the soil and subsoil to a depth of twelve feet it would appear that the problem is not merely a physical one but that the chemical conditions also play an important part. Experiments conducted by this officer on the reclamation of Saline lands have shown that both scraping and flooding are capable of improving the land.

Miscellaneous.—The Hydrogen Ion concentration of soils and the variations induced under manureal treatments is under investigations by Carbery in Bengal and also by the Officers of the Indian Tea Association.

The Officiating Agricultural Chemist, Bihar and Orissa, is studying the action of Gypsum on the solubility of the soil constituents and its effect on the rate of percolation through a layer of soil which normally is almost impervious.

MANURES AND MANURING.

Field Experiments.—Norris has published a detailed review of the results obtained with regard to the yields and variations in the composition of the crops from a series of permanent manurial plots laid down at Coimbatore in 1909.

In South Bhagalpur the field experiments with green manures and superphosphate have shown residual increase in Nitrogen or P_2O_5 and it appears probable that annual application will have to be given if increased crop production is to be maintained.

Narasinha Iyenger reports that experiments in Mysore on the general manurial requirements of red soils and heavy paddy soils have indicated that nitrogen and P_2O_5 are required and that there is no response to potash manuring. He has also received confirmation of the conclusions previously drawn with regard to the manurial requirements of sugar-cane and areca palms in Mysore.

Farmyard and Organic Manures.—Lander has published the results of experiments designed to test the residual effect of Green manure in increasing the crop yields and finds that the effect is wearing off in some of the plots after four years. Carbery is investigating the fermentation of green manure in laterite soils in order to determine the conditions which lead to the greatest retention of the nitrogen.

In Madras an enquiry has been initiated the object of which is to obtain information regarding the bulk of manure obtained from one pair of cattle under different methods of storage and the manurial value of the same as indicated by analysis and croping trials.

The conditions under which artificial farmyard manure can be prepared efficiently and economically are being studied by the officers of the Madras

and Central Provinces department of agriculture and also at the Indian Institute of Science. This line of investigation would appear to be of great importance as it permits the employment of many waste materials for the formation of a valuable manure.

The Agricultural Chemist to the Government of Mysore has for several years been investigating the availability of nitrogenous manure and finds that sulphate of ammonia gives the best result. Of the oil cakes employed ground-nut and castor yield equal results whereas safflower cake is distinctly inferior.

The Officers of the Punjab Agricultural Department are making a detailed study of the effect of city sullage water on various crops.

Artificials Nitrogenous Manures.—Norris in Madras, has shown that when Calcium Cyanamide is applied to a soil it is rapidly and successively converted into urea and ammonia the latter being finally oxidized to nitrates. The condition leading to the formation of dicyanodiamide seem to be (1) the use of excessive amounts of nitrolin and (2) its uneven distribution. In either case alkaline conditions are produced which favour the production of dicyanodiamide which in turn appears to check nitrification.

Plymen has conducted experiments to test the value of Urea as a manure in comparison with such manures as Nitrate of Soda, Sulphate of Ammonia, etc.

Phosphate Manures.—Das at Pusa has continued his investigation into the determination of the " available " P_2O_5 of calcarious soils and found that extraction by a weak solution of K_2CO_3 gave values for available P_2O_5 which were not affected to any appreciable extent by varying amounts of $CaCO_3$. Applying the method to Pusa Soils with a known manureal history he finds that a differentiation is obtained which can be corelated with the manureal treatment and cropping value.

CROPS AND AGRICULTURAL PRODUCE.

Oils and Oil Seeds.—The content of essential oil in Cubeles, Kochoora root, Xanthoxylum rhetsa seeds has been examined in the laboratory of Professor Sudborough and an enquiry into the constituents of local ginger-grass oil has also been carried out. This same laboratory has also worked upon the composition of neem, punna, marote, rape, hongay, cashewnut, rocket, mustard and niger oils.

The Officiating Agricultural Chemist, Bihar and Orissa, has carried out experiments to determine the effect of varying manurial treatment upon the oil content of Castor Seeds.

Sugar Cane.—Clarke has published the results of the systematic trial on the field scale of the first series of Coimbatore seedlings. He found on seedling (CO 214) to be of considerable merit and of a type suited to U. P. conditions.

In Bihar and Orissa ripening tests of cane grown at Ranchi and Sepaya were carried out and the results have been prepared for publication.

Viswanath has extended the application of his refractometric method of testing cane in the field and finds that it yields a useful criterion for judging the ripeness of cane in varietal and manurial tests. In regard to after-ripening he finds the increase in sugar at the time of ripening occurs at the expense of the gummy and cellulose material of the cane.

Carbery has carried out manurial tests and finds that the shortage of lime is corellated with the high percentages of non-crystallizable sugar in the canes grown in the Dacca farm.

Sanyal at Pusa has been able to show that canes windrowed so as to be protected from rain are preserved in good condition when the same cane windrowed in the open rapidly deteriorated. This confirms his previous conclusions drawn from experiments carried out at Pusa and in the North-West Frontier Province.

Rice.—Charlton in Burma has devised a simple, convenient and cheap method of abolishing the nuisance due to the parboiling of paddy which is now in successful operation in several large mills.

Burma Beans.—By means of single plant selection of Burma Beans satisfactory results have been obtained in that several strains have been isolated which show a diminution of HCN content to the extent of about 30 per cent. In addition Charlton has investigated the effect of methods of storage on the variation in hydrolytic activity and the content of cyanogenetic glucoside and has published a note on the determination of Prussic Acid.

Warth has published a summary of his work on these beans.

Opium.—Annett and his co-workers has published paper on the estimation of codeine. Narcotine and Papaverine and on an investigation into the loss of Morphine content of powdered opium during storage. Their studies on the Enzymes of the Latex of Indian Poppy and the influence of Papaverine on the Optical activity of Norcotine in acid solution have also been published.

Work on the ash constituents of opium and on the method of isolating a purer form of the wax is being carried on and the study of the non-alkaloidal nitrogenous matters of opium has been taken up.

Tea.—The work of the Scientific Department of the Indian Tea Association has been largely concerned with investigations into factors influencing the quality of tea. (*a*) The study of the variation in tannin, N. K_2O and P_2O_5 by periodic analysis of the first leaf. (*b*) Variation in quality as determined by the tester and tannin content by analysis brought about by varying conditions of fermentation. (*c*) An investigation into the nature of tea tannin.

Miscellaneous.—Work in connection with the improvement of the cardamom crop at Sirsi is being studied by Sahasrabuddhi particularly from the soil biological point of view.

Lieut.-Col. R. McCarrison who is in charge of the Deficiency Diseases Inquiry carried out a number of feeding tests with Ragi (Eleusine coracana),

from the permanent manurial plots at Coimbatore and although the trials are incomplete very striking and unexpected results have been obtained. With the exception of the cattle manure plot which gives the best results, the plots receiving nitrogen have all given a grain having a lower food value than the non-nitrogenous plots. In conjunction with Norris an investigation into the causes of beri-beri is being carried out.

Viswanath has continued his investigation on the malting of cholam or juar and has shown that this grain is quite suitable for the preparation of malted foods.

Prof. Fowler of the Indian Institute of Science and his co-workers is continuing his investigation into the fermentation of cellulose material for the production of power alcohol and in this connection the possibility of utilizing the cob of Indian maize and waste coir dust have received attention.

Marsden has conducted an investigation on the bio-chemistry of coir-retting and has confirmed the conclusion previously arrived at that the process is due to organisms in the husk which are able to attack and destroy the " gum " and mucilage-yielding substances which bind the fibres together.

ANIMAL NUTRITION.

Mr. Warth has examined a considerable number of samples of Juar from different parts of India for their food value. Considerable variation in quality was found.

The same officer has determined the digestion co-efficients of nine typical concentrates and also for paddy straw. In regard to the latter fodder the average digestion co-efficients obtained for fibre and Nitrogen-free extract were 72 and 44 respectively whereas the corresponding averages found in American experiments are 59 and 46.

In regard to the nitrogen balance in five experiments out of six it was found that more nitrogen was excreted in the faces than was given with the straw, the exception being associated with an unusually high N. content of the fodder given. The conclusion arrived at is that small differences in the N. contents of the straw may cause very significant differences in nutritive effect.

In the course of work in connection with maintainance rations it was found that the nutritive ratio of the digested food was 1 : 16·2. This ratio is a very wide one but probably must be considered normal for bullocks in India.

Lander has determined the digestibility co-efficient of bhusa, gram, maize and sheesham leaves and the results are being prepared for publication.

The Agricultural Chemist, Mysore State, has carried out feeding experiments with calves and has shown that a mixed ration of bran and ground nut cake is better than one of either alone. Heifers fed on the mixed ration appear to come to maturity earlier than those fed on bran alone.

APPLIED CHEMISTRY

PART II.—FOREST CHEMISTRY

BY

J. L. SIMONSEN,

Forest Chemist, Forest Research Institute, Dehra Dun.

Essential Oils. (1) **Pinus longifolia.**—The terpene d—$\triangle^{-3}$ carene obtained from the oleo-resin of *P. longifolia* has been re-examined during the year and the products formed on oxidation with potassium permanganate investigated. (Journ. Chem. Soc. Trans. 1923, *123*, 549.)

(2) **Pinus Merkusii.**—The turpentine from the oleo-resin of *P. Merkusii* has been studied and the constituents have been shown to be qualitatively identical with those present in the oil from the oleo-resin of *P. longifolia*. The quantity of *d*-$\triangle^{-3}$ carene and *d*-longifolene present is small and the turpentine is of excellent quality. A paper on the subject is in the press. (The Constituents of some Indian Essential Oils. Pt. XII.)

(3) **Pinus Gerardiana.**—The turpentine from this rare oleo-resin has been examined, the oil consisting almost solely of d-L and d-β-pinene (Ind. For. Rec. Vol. IX, p. 345). The turpentines obtained from the oleo-resins of all the species of *Pinus* occurring in India have now been studied.

(4) **Pinus Excelsa.**—A sample of the leaf oil of *Pinus Excelsa* supplied by Col. C. R. Johnson of Abbottabad has been investigated. It possesses no economic value. (Ind. For. Rec., Vol. IX, p. 341.)

(5) **Boswellia serrata.**—A detailed examination of the oil from the oleo-gum-resin of *B. serrata* has been made. The main constituent was found to be *d-L*-thujene, a terpene not previously found in nature. (Ind. For. Rec., Vol. IX, p. 289.)

(6) **Andropogon Jwarancusa, Jones.**—The terpene present in the oil has been shown to be d-$\triangle^{-4}$ carene, the second terpene of the carene group to be found in nature. (Journ. Chem. Soc. Trans. 1922, *121*, 2292.)

(7) **Cupressus torulosa.**—The oil from the leaves of *C. torulosa* has been examined (Ind. For. Rec., Vol. X, 1). The principal constituent of the oil was found to be *d*-sabinene.

(8) **Cympopogon Cæsius.**—Moudgill and Krishna Iyer have separated the oil from this grass and determined its constituents. (Perf. Ess. Oil Rec 1922, *13*, 292.)

(9) **Sandal Wood.**—Sanjiva Rau and Sudborough have published a valuable paper on the chemistry of Australian "Sandal wood oil", which is obtained from *Fusanus Spicatus* R. Br. (Journ. Ind. Inst. of Sc., Vol. V, p. 163.)

Fixed oils.—A number of important papers dealing with the utilisation of fixed oils have appeared during the year. They do not lend themselves to summarisation and reference should be made to the original publications. (The Relation between Iodine Values and Refractive Indices of some Hardened Vegetable Oils. Pt. 1 Sudborough, Watson and Athawale, Journ. Ind. Inst. of Sc., Vol. V, p. 47, Oil Splitting by Castor-seed Lipase Pts. V-VII, Sudborough and Watson, loc. cit. p. 119. Some West Coast Vegetable Oils. Joseph and Sudborough loc. cit. p. 133.)

The oils from the seeds of *Aleurites Montana* and *Salvia plebeia* have been studied at Dehra Dun.

Miscellaneous.—The chemistry of shellac has been decidedly advanced as the result of a valuable investigation by Harries and Nagel. (Ber. 1922, *55B*. 3833.)

Forster and Saville have commenced an investigation of the chemistry of gardenin, a crystalline constituent of the gum of *Gardenia lucida* first isolated many years ago by Shenstone.

Further work on the constitution of catechin has been published by Nierenstein and Freudenberg whose conflicting results are difficult to reconcile.

Marsden (Journ. Ind. Inst. of Sc., Vol. V, 157) has studied once more the question of utilising tamarind as a source of tartaric acid and also as a source of alcohol.

ASTRONOMY

BY

J. H. FIELD, ESQ.,

Offg. Director-General of Observatories.

Solar Physics—Researches in Solar Physics were carried on at Kodaikanal Observatory. The Observatory takes a prominent part in the world-wide programme of the International Astronomical Union. At a meeting in Rome in 1922 the Union allotted to India (Kodaikanal) the task of collecting from contributing observatories in other countries photographs of solar prominences and of the sun's disc taken in monochromatic (Hα) light and measuring them systematically. This work was begun regularly in January 1923.

Routine work.—Daily spectroheliographic records are obtained in calcium and in hydrogen light ; the routine work also includes visual examination of sunspots and faculae, sunspot spectra, and bright lines or displaced lines in spots and in prominences. The data resulting from the work are presented in the India Weather Review (Annual Summary), while for more technical purposes bulletins and memoirs of the Observatory are issued. Of the former 73 have appeared and of the latter 2 have been published. [4]

Spectroscopic research.—The study of the displacements of spectrum lines in the electric arc when extraneous substances are introduced has been continued. The effect of additional substances on copper lines and also the effects on certain calcium lines have been tried, but no effect greater than that given by introducing sodium into a copper arc has been found. It is especially important to examine the effect on a long arc since many wave-length determinations have been made in the past without considering the effect of other substances present in the arc ; it has been found that the effects in a long arc are small, but sufficient experiments have not been made to establish the precise magnitude of the displacements. The displacements and appearance of spectrum lines in the arc and sun have been shown to follow very closely their behaviour in an electric field and hence it is concluded that the effects observed in the arc are the results of the electrical field in which the atoms find themselves in consequence of the electrically charged ions surrounding them. It is found that the field in the sun is of the order of 2000 volts per cm. less than that at the centre of the electric arc, and near the poles of the arc is 4000 volts per cm. greater than at the centre of the arc. Our knowledge of the ionisation in the arc is not sufficiently complete to enable any deduction to be made concerning the ionisation in the sun except that it would appear that the lower density in the sun is more than sufficient to compensate the increased ionisation due to the higher temperature.

It has been shown that in addition to the barium series previously found there are several spectral series showing the anomaly of changing the characteristics of the lines in the course of the series. The change is parallel to the behaviour in an electric field so far as evidence of the latter is available.

Mr. Evershed continued the study of the displacement of the sodium lines D_1, D_2 in the sun. After correcting for the effect of pressure in these two lines, he derived a mean shift of +0·017 A, whereas the Einstein displacement should be +0·012 A. Whilst the results tend to conform to the Einstein theory, further investigation is necessary before a definite judgment can be given. The speed of solar rotation deduced from the D lines was 1·937 km/sec. in close agreement with lines at a lower level in the sun, whereas a higher value was expected.

The prism spectrograph mentioned in the last report was again used by Mr. Evershed for determining the shifts in the spectrum of sunlight reflected from Venus. He concluded that the displacements were identical on the two sides of the sun facing the earth and turned away from the earth respectively. Mr. Evershed also compared the solar displacements of iron and cyanogen lines, obtained with this spectrograph, with those obtained previously with the grating spectrograph, and found that some lines did not show the same displacement as formerly, the maximum difference amounting to 0·005 A at the centre of the sun's disc and 0·008 A at the sun's limb.

An important feature of the year was the eclipse expedition to Wallal (W. Australia) led by Mr. Evershed. The main purpose of the expedition was to photograph the star field surrounding the sun, for determining the deflection of light by gravitation of the sun. In spite of elaborate preparations the results were disappointing chiefly on account of the defective coelostat which had to be used and also on account of the unusual faintness of the corona during the eclipse.

METEOROLOGY

BY

J. H. FIELD, ESQ.,

Offg. Director-General of Observatories.

Upper Air.—Flights of pilot balloons were continued daily at the upper air stations, Agra, Simla, Lahore, Quetta, Calcutta, Akyab, and with the co-operation of the Government of Mysore at Bangalore. Similar work at Peshawar was stopped as a temporary measure in the early part of the year.

At the Agra Observatory current work of out-stations was scrutinised and computations of upper air data were carried out.

Some headway was made in preparing for the resumption of meteorograph balloon flights.

The work in arrears was not cleared entirely up to date; completion might have been possible had it not been necessary in the winter to send a part of the computing and observing staff as "Meteor" parties to supply daily information about upper air currents to a number of Artillery Practice Camps. This work has been greatly appreciated.

The following papers in connection with upper air were published during the year:—

(*i*) Mean monthly characters of upper air winds deduced from the flights of pilot balloons at thirteen stations in India during the period 1910 to 1919—by J. H. Field.

(*ii*) On the seat of activity in the Upper Air—by P. C. Mahalanobis.

(*iii*) On errors of observation and upper air relationships—by P. C. Mahalanobis.

Several papers written in 1921, on Upper Air observations made during the years 1914-1919, were taken in hand for publication.

General Meteorology.—A paper "On exposures of thermometers in India," written in 1920 was published. It was based on experimental observations with a view to determine the comparative merits of the usual method of placing thermometers at observatories under thatched sheds and of other kinds of exposure like the Stevenson screen.

A paper on "A preliminary study of world weather" by Dr. Walker was prepared and is about to be published in the series of Memoirs on "Correlation in seasonal variation of weather."

It has been discovered that the westerly components of upper air winds at Agra at about the 6 km. level, as prevailing from the middle of September to the middle of October in the year, show close relationship with the precipitation in northwest India in the winter following. The matter is being followed up in view of its probable high value should the relationship be supported by the experience of a longer series of years.

TERRESTRIAL MAGNETISM

BY

J. H. FIELD, ESQ.,

Offg. Director-General of Observatories.

Alibag Magnetic Observatory.—The declinometer, the horizontal and vertical force magnetometers and variometers as well as the magnetographs were in use throughout the year.

In connection with the scheme of international co-operation for studying the effect of the total solar eclipse of the 21st September 1922 on magnetic elements special observations were taken at Alibag from the 19th to the 23rd September 1922.

The instruments and the routine work are described in the Annual Report of the Director of the Observatory for 1921 and also in the quinquennial volume of the data collected at Bombay and Alibag observatories for 1911-15.

The latter publication has been replaced by an Annual Volume and in future the more important of the magnetic data will be presented in it.

Magnetic Survey.—No. 18 Party (Magnetic) Survey of India.—The declination, horizontal force and vertical force magnetographs continued in operation throughout the year at the Dehra Dun and Toungoo observatories, and daily absolute magnetic observations were taken regularly by the observers in charge. The observatories were visited during the field season and observations of declination, dip and horizontal force, were taken for the comparison of instruments.

The Kodaikanal and Alibag observatories, under the control of the Meteorological Department, were also visited for the same purpose.

Observations at Repeat Stations.—Magnetic observations were taken this field season at the six repeat stations—Quetta, Karachi, Bina, Dibrugarh, Barrackpore and Waltair: these stations were visited to supplement the 5-yearly observations at all repeat stations in order to obtain accurate determinations of the annual changes in the magnetic elements.

Publication of the results of the magnetic survey.—The results of the observations at the observatories, repeat and field stations, reduced to the epochs 1909-0 and 1920-0 are in press and should soon be published.

Special magnetic observations.—In response to an appeal by Dr. L. A. Bauer of the Carnegie Institution of Washington, special observations in connection with the solar eclipse of the 21st September 1922, were taken at Dehra Dun, Toungoo and Kodaikanal. The three observatories were favour-

ably situated within the shadow belt of the eclipse. Declination, dip and horizontal force were observed at Dehra Dun, while at Toungoo and Kodaikanal only declination observations were taken.

Mean values of the magnetic elements at observatories in 1922, derived from readings excluding those when 'great disturbances' prevailed.

Observatory.	Latitude and Longitude.	Dip.	Declination.	H. F.	V. F.
	° ′ ″	° ′	° ′	C. G. S. Units.	C. G. S. Units.
Dehra Dun	30 19 19 N 78 3 19 E	N. 45 8·6	E. 1 43·2	0·32927	0·33091
Toungoo	18 55 45 N 96 27 3 E	N. 23 7·2	W. 0 29·7	0·39156	0·16717
Kodaikanal	10 13 50 N 77 27 46 E	N. 4 40·1	W. 1 58·7	0·37878	0·03093
Alibag	18 38 36 N 72 52 12 E	N. 25 5	E. 0 12·6	0·36967	0·17303

GEOLOGY

BY

DR. E. H. PASCOE, M.A., Sc.D., D.Sc., F.G.S., F.A.S.B.,
Director, Geological Survey of India.

Meteorites.—A meteorite is reported to have fallen at Quetta, January 1923, and to have set fire to a stack of *bhoosa*. The iron bands of the *bhoosa* were melted by the fire, and if a meteorite did actually fall, it became fused with this iron. A large quantity of ferruginous material was found after the fire had been extinguished, and proved to be a slag consisting largely of iron and silicate of iron, in which no meteoric texture could be recognised.

Palæontology.—Mr. LaTouche's Palæontological Index will be issued shortly. Various papers on the *Olividæ*, *Harpidæ*, *Marginellidæ*, *Volutidæ*, *Mitridæ*, *Fusidæ*, *Turbinellidæ*, *Chrysodomidæ*, *Strepturidæ*, *Buccinidæ*, *Vassidæ*, and *Columbellidæ* by the late Mr. E. Vredenburg have been published. The same writer is also responsible for an analysis of the Singu Fauna and a description of the zone fossil, *Ampullina* (*Megatylotus*) *birmanica*. Determinative work has been carried out also on the Triassic rocks of the Aden Hinterland, the Triassic rocks of Bikanir, the Nummulitic of the North-West Frontier Province and of Sind, the Tertiary of Burma, Assam and Persia, and the Carboniferous and Cretaceous of Tibet.

Geological Surveys.—The survey of the iron ore deposits in Singhbhum and the Feudatory States of Bihar and Orissa was continued, as was also the general systematic survey of the Central Provinces. In the Mergui district of Lower Burma a traverse was made from Tenasserim into Siam, in continuation of the general survey of the Mergui district. Coarse grained granite was found to occupy the main mass of the hill range forming the boundary between Burma and Siam. Some evidence was found of the retreat of the sea on the Siamese coast. Work in Tavoy was interrupted by the Mount Everest Expedition. The island of Elphinstone was found to coincide with the foci of the eruptions which took place during the deposition of the Mergui series. In the Southern Shan States the Loi-an coal-field was surveyed. Surveys in the Minbu and Pakokku districts were continued. The survey of the Betul district was practically completed. A further examination of Chitral brought out interesting facts in connection with the Devonian beds. The filling up of the blank on the geological map in the Hyderabad area was almost completed. Systematic surveys in the Siwalik foothills of the Punjab and in the Poonch Ilaqa were proceeded with.

Economic Enquiries.—Investigations were made and information recorded regarding the following minerals:—Aquamarine, arsenic, asbestos,

copper, manganese, garnets, graphite and sulphur in Chitral, bauxite in the Kolhapur State, lignite in the Rannagar Raj, Tertiary coal in Mergui, Gondwana coal in the Southern Shan States, fire-clay and brick-clay in the Jubbulpore district, natural gas in Baroda, iron ore in Bihar and Orissa and the Northern Shan States, kaolin in the Ratnagiri district, mica in Kodarma, oil shales in Mergui, salt in Shwebo and Sagaing and in the Sambhar lake of Rajputana, and sillimanite in the Khasi Hills. Amongst engineering questions dam sites at Cherrapunji in Assam, on the Damodar and Barakar rivers in Bengal, on the Yunzalin river in Upper Burma and on the Sutlej in the Punjab were reported upon. The water supply at the Great Indian Peninsula railway near Itarsi and the general supply at Jubbulpore were taken up.

GEODESY

BY

LIEUT.-COL. H. McC. COWIE, R.E.,

Superintendent of the Trigonometrical Survey.

TIDAL OPERATIONS.

During the past year tidal registration by means of automatic gauges was carried out at the following ports:—

Aden, Karachi, Bombay (Apollo-Bandar), Bombay (Prince's Dock), Madras, Kidderpore, Rangoon, Moulmein and Port Blair.

All the tide gauges have worked satisfactorily, and there have been no serious breaks in the tidal registration.

All the tidal observatories except Aden and Port Blair, were inspected during the year and the gauges thoroughly overhauled and put into working order.

In addition to the automatic tidal registration at the nine ports named above, observations of high and low water on tide poles were taken during day light at Bhavnagar, Chittagong and Akyab, with the object of testing the accuracy of predictions which were based on tidal registration taken many years ago.

The Director, Inland Water Transport, Basrah, has continued to supply to this Department tidal observations taken on an automatic tide gauge erected at Margil by the Port Officer, Basrah. On the basis of these observations, data for the preparation of tide-tables for Basrah for the year 1923 were prepared and used on the tide-predicting machine. This machine was brought out from England and erected in the office of the Superintendent, Trigonometrical Survey, Dehra Dun, in October 1921. The tide-tables for Basrah for 1923 were published and forwarded to the Director, Inland Water Transport, the Port Officer, Basrah, and the Director of the Royal Indian Marine, Bombay, in September 1922.

The predictions of tides and preparation of tide-tables for Indian Ports as well as for Basrah from 1923 were undertaken entirely in India. The tables for 1924 will also be published shortly.

LEVELLING OPERATIONS.

During the season 1922-23 the following lines of precise levelling were run:—

A.—In the Punjab.

I. For the new level net.—

(*a*) Mithra to Khānpur forming part of the line 102 of the level net.

(*b*) Khānpur to Reti forming part of the line 105 of the level net.

In all 81 miles of levelling of high precision were completed on the "fore and back" system.

II. For the Sutlej Valley Irrigation Project.—

(*a*) Kasūr to Lodhrān.
(*b*) Ratta Tibba to left bank of river Sutlej *viâ* Luddakh.
(*c*) Kutabpur *viâ* Khān Bela to Adamwāhan.
(*d*) Lodhrān to N. W. railway bridge over the Sutlej.
(*e*) Khudiān to Lodhrān.
(*f*) From near Amruka railway station to Fāzilka.
(*g*) Fāzilka to Ferozepore (Revision of part of main line No. 57).
(*h*) Dingarh to Khānpur *viâ* Mithra, Reti and Chacharan.
(*i*) Chacharan to Khān Bela.
(*j*) N.W. railway bridge over the Sutlej to near Amruka railway station *viâ* Bahāwalpur, Marot and Walar.
(*k*) Kandhyawāla *viâ* Hāsilpur to left bank of the Sutlej.

This work was undertaken at the request of the Public Works Department (Irrigation Branch), Punjab, in order to furnish accurate benchmarks referred to a common origin, which would enable the Irrigation Engineers to co-ordinate all their cross levels throughout the entire length of the main canals and their distributaries. The total distance levelled on the system of "simultaneous double levelling" was 1,250 miles, of which half lay in the Bahāwalpur State. In addition to this, 13,750 miles of tertiary levelling were run over a previously demarcated area of about 2,045 square miles in British territory for the purposes of a detailed contour map.

B.—In the Bombay Presidency.

I. For the new level net.—

(*a*) Reti to Jacobabād, forming part of line No. 105 of the level net; about 137 miles.

II. For the Sukkur Barrage Project.—

(*a*) Shahpur to Mīrpur Khās.
(*b*) Jhol to Khipro.
(*c*) Mīrpur Khās to Uemarkot.
(*d*) Mīrpur Khās to Dadah.
(*e*) Mathli to Digri.
(*f*) Khipro to B. M. No. 7 of line C.
(*g*) Umarkot to Wungo.
(*h*) Wungo to Dadah.
(*i*) Dadah to Mathli.

This was undertaken at the request of the Public Works Department (Irrigation) in connection with the Sukkur Barrage Project. The total distance of 387 miles was executed by simultaneous double levelling

III. Ahmadnagar to Dhond.

This line was undertaken for the purposes of an investigation into the errors of a level-circuit.

IV. For the Ghatprabha canal system.

(*a*) Sankeshwar to Kalādgi *viâ* Hukeri road, Yadvad and Mudhol.
(*b*) Hukeri road to Jodhatti.
(*c*) Jodhatti to Mudhol.
(*d*) Mudhol to Kudchi *viâ* Jāmkhandi.
(*e*) Kudchi to Jodhatti.

This work was undertaken at the request of the Bombay Public Works Department (Irrigation) in connection with irrigation in the Deccan.

The total distance levelled was 170 miles, carried out by simultaneous double levelling.

C.—In the Madras Presidency.

Gooty to Ongole *viâ* Banganapalle, Giddalur, Cumbum, Podili and Uppalapaud, with a branch-line to Atmakur *viâ* Nandyal.

The purpose of this line was to break up the large circuit Gooty-Arkonam—Madras-Bezwada-Gulbarga-Raichūr-Gooty. In the course of this work the heights of selected bench marks at Giddalur, Cumbum and Podili were determined with a view to investigating possible changes of level in an earthquake area.

This line was 220 miles in length, and was executed by simultaneous double levelling.

D.—In Burma.

I. For the scheme of the double embankment of the Irrawaddy.—

(*a*) Nyaungzaye to Yandoon, with a branch line to Malëtto, along the left bank of the Irrawaddy and the China Bakīr.
(*b*) Yandoon to Kandin, along the Panhlaing, Kok-ka-wa and Hlaing rivers, and along the P. W. D. road.

II. For the correlation of the tide-gauge readings in the Irrawaddy Delta.

(*a*) Maubin to Bassein.
(*b*) Sagamya to Pantanaw.

Both (I) and (II) were carried out at the request of the Burma Public Works Department (Irrigation).

The total distance of 610 miles was done by simultaneous double levelling.

BOTANY

I.—BOTANICAL SURVEY

BY

C. C. CALDER, ESQ., B.Sc., B.Sc. (AGRI.), F.L.S.,
Offg. Director, Botanical Survey of India.

I. **Systematic.—Eastern India and Burma.**—Apart from the tours of the Director undertaken primarily in connection with Cinchona work but taken advantage of for Botanical purposes as well, no touring was possible during the year. Work in the herbarium has therefore been confined to collections already awaiting examination and to identifications of current consignments from outside collectors.

On the systematic side a great variety of study during the year calls for record. With the development of Botanical Schools in connection with Indian Universities and Colleges the range of study tends yearly to increase. Practically all the main groups of the vegetable kingdom now have their students and an increasing amount of attention is being given to many groups of plants which for one reason or another have received scant attention in the past. Thus the Algae, the Liverworts and the Fungi now have their taxonomists and a mass of literature on these as well as on the higher plants is finding issue in new botanical journals and papers.

Mr. Haines' further study of the flora of Bihar and Orissa and the Central Provinces has revealed the existence of the following four species new to science :—*Stereospermum angustifolium*, *Premna calycina*, *Leucas helicterifolia* and *Cureuma sulcata*. Full descriptions of these have been published in the Decades Kewensis section of the Kew Bulletin.

In Notes from the Royal Botanic Garden, Edinburgh, are published the last diagnoses by Prof. Balfour of a large number of Asiatic Rhododendrons. Seventy species in all are dealt with including some 29 from Burma and the North-East Himalaya collected by Messrs. Farrer, Kingdom Ward and Cooper, also a large number from China and Tibet collected by Forrest. Mlle Camus has described a new genus of the Bambuseae, *Neohouzeaua*, one species of which under the name *Teinostachyum Dullooa*, Gamble has been known from Bengal eastward in North-East India and in Burma. It is now reported from French possessions in South-East Asia. Another species belonging to the same genus, *N. tavoyana*, Gamble originally *Bambusa Helferi* has been redescribed by Mr. Gamble in the Kew Bulletin where he gives an account of the

new genus and the effect of its adoption on the nomenclature of certain previously known Bamboos. An excellent local flora dealing with the vegetation of the Andamans from the forest officers' point of view has appeared in Mr. C. E. Parkinson's latest publication. The keys given furnish the field botanist with a ready means of identifying material as he goes along and the fuller descriptions in the body of the work supplement the information of the keys which are artificial. From Mr. Parkinson's collection in the islands Mr. Hutchinson has described a new species—*Orphea torulosa*—belonging to the Anonaceae.

In Burma the temporary disorganisation caused by the transfer of the Cinchona plantations and the heavy work entailed in opening up the new area have prevented Mr. Russell and his assistants from doing as much field botanical work as might have been possible under more normal conditions. During a tour to the Mergui area late in the year the Officiating Director took occasion to collect and supervise collections. An additional mass of material over that collected in Tavoy is accumulating and will form the basis for future work on the systematic botany of the jungles lying between Mergui and the gulf of Siam.

The Algae of Bengal has been made the special subject of study by Prof. Bruhl and his assistants in the Biological Laboratories, Calcutta. Treatises on Indian bark algae and *Compsopogon* have appeared in the Journal of the Department of Science during the year; several species of bark algae new to science have been described while the distribution in Bengal of numerous previously known forms is being recorded.

The Polyporaceae of Bengal forms a subject of study for Prof. S. R. Bose; the results of his researches are being issued in the Bulletin of the Carmichael Medical College.

Northern India.—The most important botanical work having a special reference to this area published during the year has been Mr. Osmaston's treatise on the Forest Communities of the Garhwal Himalaya. The work is an oecological study of the tract and the conditions affecting the vegetation. The formations, associations and societies are all described and a series of excellent photographs illustrates the work.

The following new species of plants from Northern India have had their descriptions published:—*Acacia pseudoeburnea*, from Kumaon, Hardwar, etc., *Indigofera rubro-violacea* from the Chamba State and Kashmir; *Leptodermis kumaonensis* from Garhwal and *Astragalus aegacanthoides* from Kumaon.

Mr. W. B. Turrill has a paper on a question of nomenclature in the Cyperaceae raised in connection with his work on this group for the Flora of the Upper Gangetic Plain.

The Liverworts of the North-West Himalaya are the special subject of study of Prof. Kashyap and his school at the University of the Punjab. Amongst others Prof. Kashyap has interested himself in plant immigrants. In a paper read at the meeting of the Indian Science Congress he gives as account of foreign species establishing themselves about Lahore.

During the year Prof. Hallberg, late of St. Xavier's College, Bombay, made an expedition to the North-West to discover the distribution, abundance, times of flowering, etc., of the forms of *Artemisia* found over the area and known to contain santonin. So far as obtaining material rich in santonin was concerned the expedition failed, but a whole crop of questions on the reasons why santonin was not found have been raised. Quite an appreciable amount of the drug had previously been extracted from the same plant growing in the same area. The reasons why no santonin was obtained on this occasion are obscure, but the subject is of great economic importance and it deserves to be further investigated. As regards plants from the North-West the collections of the Botanical Survey are the richer by many thousands of sheets as the result of Prof. Hallberg's tour.

Western India.—Preliminary to a continuation of his work on the physiological anatomy of the plants of the Indian desert Prof. Sabnis is compiling a list of plants of the desert of Sind. Localities in Sind and the general distribution of the different species found are cited. In 1918 Prof. Saxton and Mr. Sedgwick published in the *Records of the Botanical Survey of India* an account of the plants of Northern Gujarat. Since then many additions have been made and these, with the intention of supplying information supplementary to the main account, have now been published.

In the same publication a further part comprising the families Labiatae to Ceratophyllaceae of Ethelbert Blatter's Flora Arabica has appeared.

A very handy account of the ferns of Bombay has appeared in Messrs. Blatter and D'Almeida latest publication on this group. The work is illustrated by figures showing the essential morphological details and in many cases the general appearance of the frond or plant is also given.

A new Indian grass—*Urochlöa marathensis*—from the Bombay Presidency has been described by I. T. Henrard in the publication of the Van's Rijks Herbarium. The new species comes near *U. Helopus* described by Stapf but material is not sufficient to determine it as being identical. In the small amount of material available differences are evident and the author has thought these sufficiently marked to warrant, tentatively, specific distinction.

Southern India.—Mr. Gamble has described the following new species from the Southern part of the peninsula—*Torenia courtallensis, Didy mocarpus Fischeri, Toxocarpus Beddomei, Toxocarpus palghatensis, Legustrum travancorium, Brachystelma Bourneae* and *Brachystelma Rangacharii*—while Dr. Stapf in Hooker's Icones has fully described and figured new combination in *Cyrtococcum trigonum* and *Capillipodium glaucopsis* two new grasses. The most important botanical work dealing with the higher plants and connected with this division at present under preparation is Mr. Gamble's Flora of the Madras Presidency. Amongst the lower plants a new genus of Moss.—*Beddomiella*—founded on material collected many years ago by Beddome in the Nilgiris has been described by Mr. H. N. Dixon.

General.—Prof. P. F. Fyson has completed his study of the Indian Eriocaulons. His results are published in the Journal of Indian Botany and

in the reprint form a handy guide to the student in this rather difficult group of plants.

The Indian Ophioglossums are dealt with by Prof. I. D. D'Almeida of St. Xaviers' College, Bombay. The extreme variability of the individuals comprising the different species has been the cause of much splitting in the genus. Prof. D'Almeida has reviewed the characters which seem to him to merit consideration from the systematist; the group is keyed re-arranged and described; Indian distributions are dealt with and references made to the various collections on which the work is based.

The Fungi of Ceylon continue to receive the attention of Mr. T. Petch. Additions to the Fungus flora of the island are being published in the Annals of the Royal Botanic Garden, Peradeniya. All additions, no matter to what group belonging, are taken up. As most of the fungi are not endemic in the island but extend their distribution to the Indian Peninsula the work is of much value to students of the fungus flora of India.

A new colonial member of the Isokontae, a group of algae, collected in the inland fresh waters of Ceylon by Prof. F. E. Fritsch, is described by W. B. Crow in the Annals of Botany where the comparative morphology and systematic relationships of the new species are described.

Besides the above many works on systematic botany dealing with groups of plants, some numbers of which extend their distribution to India, have found publication during the year. The genus *Calendula* is dealt with by Hallier, the genus *Ptyssiglottis* by Moore, the Euphorbiaceae-Phyllanthoideae Phyllantheae by Pax and Hoffman and the Compositae-Hieracium by Zahn, the last two in the Pflanzenreich. Pfeiffer has a monograph of the Isoetaceae in the Annals of the Missouri Botanical Gardens.

Dr. Church has published an Introduction to the systematy of Indian trees, being notes arranged for students of Indian Botany at Oxford.

Sir J. C. Bose has studied the physiology of the ascent of sap in plants. Prof. Bruhl and his assistants have papers on Vitamines and an interesting and timely account of the new pond pest Eichhornia. Messrs. Dastur and Saxton have studied the vegetative methods of reproduction in certain plants and also the oecology of some plant communities in the Savannah formation.

A preliminary note on the life history of *Cedrus Deodara*, with, special reference to fertilisation and the structure of the prothallus has also been given by Mr. Saxton. Papers on the anchoring pads of *Gymnopetalum cochinchinensis*, flora prolification in *Nymphea rubra* and a note on an artifice of nector sipping birds are some of the results of Mr. Debbarman's observations during the year.

II. Economic.—The most important item under this heading continues to be Cinchona cultivation. Reference was made in last year's report to proposals for the transference of work to the Mergui District of South Burma. Conditions in the Tavoy area proved impossible and it became evident that a new location for Cinchona was inevitable. After very careful preliminary

investigation of the soil and climatic conditions in the neighbourhood of Tenasserim, proposals for a fresh start in this district were sanctioned and Mr. Russell, Superintendent of Cinchona Cultivation, with part of his essential establishment moved from Tavoy to fresh quarters situated in the foothills south of the Tenasserim Hevea plantations at Nyaungbinkwin. As conditions here seemed to provide all the essentials for Cinchona, work was started on a fairly extensive scale but not on such a scale as would prove ruinous if unforeseen events negatived the area as a source of supply of bark. By the end of the year some 1,500 ' kamras ' for seelings were in course of construction of which 150 were already carrying their stock awaiting transplanting ; a mixed labour force was busy reducing the jungle to order while roads were being pushed through to link up Cinchona camp with the outside world and to get sufficient stores through in anticipation of the time when the rains would put an end to all but the minimum of communication. The original programme provided for a ' break ' of 500 acres and clearing for a considerable part of this had already been done when the need for retrenchment forced a reduction to 250 acres. Sufficient seed for this minimum only was therefore sown and in far less time than they take to germinate in the Bengal plantations the seedlings were pushing their way through and looking the picture of health. It is, of course, much too early yet to claim success, but so far nothing has happened to cause apprehension or to create misgivings as to the ultimate results. Indeed all the evidence up to the present points strongly to the area being well suited for the purposes of a Cinchona reserve. In their early stages the seedlings were thriving so well that it seemed likely that second transplanting before being put out in permanent sites could be dispensed with. With a large number of seedlings this is what must now happen. Growth has been phenomenal and it has become impossible for lines to be built on a scale large enough and sufficiently quickly to accommodate all the seedlings. In the process of hardening the seedlings to the sun, methods which have never been deemed possible in Bengal have been successfully proved this year in Burma. The most encouraging feature of the whole scheme is, however, now available from analyses carried out on very young barks grown in the Tavoy area. The writer felt that there was a certain danger of the alkaloid content failing on account of the low elevation at which extensions had to go out. This would have been in accordance with experience gained from elevation tests in Java. No means of proving the point seemed possible until barks sufficiently old for analyses gave us data for Mergui but it was felt that an analyses of Tavoy barks grown on an average at much lower elevations than is the case in Bengal might afford useful evidence of a parallel nature.

If the Tavoy bark analyses now to hand can be taken as an indication of what may be looked for in Mergui, no more promising evidence of future success could be sought. These barks are twice as rich in quinine as Bengal barks of their age and species. When Cinchona trees grown under such adverse climatic conditions as have been experienced in Tavoy give at 2 years of age an alkaloid content of 4°/₀ and at one year old between 2°/₀ and 3°/₀—percentages attained by Bengal trees at 4 to 7 years of age—it may be argued that

Cinchona planting in South Burma has one factor of prime importance in its favour. Climatic conditions have been almost ideal; the temperature in the hot weather goes a little higher than Cinchona likes, but it is not excessive and light shade planting should easily counter its effects; rainfall possesses none of the terrors it did in Tavoy and the soil seems capable of growing any crop. Under the careful supervision of Mr. Russell and his staff a very successful fresh start has been made.

Ipecacuanha, the only other crop at present experimented with, shows evidence of being much more amenable to ordinary methods of cultivation in Burma than has ever been found to be the case in the more trying climate of Bengal. When last seen in the nurseries the young plants had developed a nice bloom and looked healthy and robust. Seed for the extended cultivation of Ipecacuanha will be made available this year from Mungpoo. Meanwhile experiments on the extraction of the drug from the dried root are being carried out at the Bengal factory, the idea being to place emetine, the finished product, on the market.

IV. Publications.—During the year the following parts of the *Records of the Botanical Survey of India* appeared:—Vol. VIII, No. 4 being a continuation of the *Flora Arabica* by the Rev. Father E. Blatter, S. J., Vol. IX, No. 3 being *Additional notes on plants of Northern Gujarat* by W. T. Saxton F.L.S., I.E.S. In the Press at present are Mr. I. H. Burkill's account of the *Botany of the Abor Expedition*. A list of the more important extra departmental publications concerned with Indian Botany is appended to this report.

BOTANY

II.—ECONOMIC BOTANY

Part I.—Agricultural Botany

BY

ALBERT HOWARD, C.I.E., M.A., A.R.C.S., F.L.S.,

Imperial Economic Botanist.

The present report, which is limited to four pages of print, deals with the progress of Agricultural Botany in India during the year ending June 30th, 1923. Under these conditions, the best course would appear to be to limit this paper to an account of the more important results published during the year and to refer the student of Indian agriculture for further details to the various other annual reports and periodicals issued by Government which deal with the same subject but in greater detail.

The following publications contain a considerable amount of information on the improvement of crops :—

(*a*) *Review of Agricultural Operations in India.*—This is an annual report, prepared by the Agricultural Adviser to the Government of India, Pusa and deals, among other matters, with the distribution of improved seed in various parts of India. It also contains a classified list of papers on Indian agriculture published during the year.

(*b*) *Scientific Reports of the Agricultural Research Institute,* Pusa (including the Report of the Sugar Bureau). Copies can be obtained from the Director, Agricultural Research Institute, Pusa, Bihar.

(*c*) *Administration Reports of the Provincial Departments of Agriculture.* Bombay, Bengal, Madras, Central Provinces, United Provinces, Punjab, Bihar and Orissa, Assam and Burma. These are issued by the Government presses in these Provinces towards the end of each year and contain a general summary of the work of the Agricultural Department (including the farm reports) and also the annual reports of the Economic Botanists. These administration reports largely form the basis of the *Annual Review of Agricultural Operations in India.*

(*d*) *Proceedings of the Board of Agriculture in India*.—This contains the programmes of work in progress in Economic Botany as well as discussions on matters relating to the Agricultural Department as a whole. Copies can be obtained from the Agricultural Adviser to the Government of India, Pusa, Bihar.

(*e*) Many of the original papers on Agricultural Botany in India are published in the following periodicals: (1) *Memoirs of the Department of Agriculture in India* (*Botanical Series*), (2) *Bulletins of the Agricultural Research Institute, Pusa and* (3) *The Agricultural Journal of India*. This latter contains classified lists of all papers published on Indian Agriculture. Copies of these publications can be obtained from the Director, Agricultural Research Institute, Pusa.

Cotton.—Mr. G. R. Hilson has published a detailed account in Pusa Bulletin 138 of his work on the measurement of the lint length, seed weight and weight of lint per seed of cotton. An improved type of cotton, known as Gadag I, for the Dharwar District of the Bombay Karnatak has been described by Mr. G. L. Kottur (*Agr. Jour. of India*, XVII, 1922, p. 347) who states that the staple is stronger and more uniform in length than the general crop. Seed for distribution is grown on the Gagad seed farm. Mr. Ram Prasad (Bull. 137, Agr. Research Institute, Pusa, 1923) finds that a relation between the length of the stigma and of the fibre is probable in some forms of the genus *Gossypium*. The author considers that this inter-relation requires to be tested further before it can be accepted as an absolute certainty.

Mr. P. S. Jivanna Rao, in the *Year Book of the Madras Agricultural Department* for 1922, has conducted a preliminary enquiry into the cause of bud and boll shedding in cotton.

The work of the Indian Central Cotton Committee has entered on a new phase. The Cotton Cess Act became law during 1923 and the Committee has now been provided with funds for the furtherance of research work on the improvement and testing of cotton. A number of grants have been made to Provincial Departments of Agriculture and towards the Institute of Plant Industry at Indore where particular attention will be paid to cotton. It has been decided to found six research studentships for the training of future investigators of cotton problems.

Sugarcane.—Mr. G. Clarke and his staff have completed a detailed study of various Coimbatore seedling canes when grown at the Sugar Experiment Station at Shahjahanpur (*Agr. Jour. of India*, XVII, 1922, p. 445). The majority of the seedlings proved to be of poor quality but one seedling of considerable merit, Co. 214, has emerged from the rigorous tests applied, as a type of cane suited to the conditions of at least one important sugar tract in the United Provinces. Mr. Wynne Sayer (*Agr. Jour. of India*, XVIII, 1923, p. 249) has given the results of various mill trials of selected Coimbatore sugarcane seedlings. The canes were grown under experiment station conditions at Pusa and were milled at Ryam factory near Darbhanga. A prelimi-

nary paper on the root systems of various varieties of sugarcane has been published by Rao Sahib T. S. Venkataraman and Mr. R. Thomas (*Agr. Jour. of India*, XVII, 1922, p. 381).

Wheat.—An account of the unit species met with in the wheats of Bihar and Orissa has been published by the Botanical Section, Pusa in the Memoirs of the Department of Agriculture in India. Some of these forms are likely to be of use in breeding as they are early, rust resistant and possess high grain quality. It is possible that one of the parents of Marquis, the celebrated Canadian variety which now covers large areas in North America, was one of these unit species.

Rice.—Mr. F. R. Parnell and his staff at Coimbatore have published a second memoir on the inheritance of characters in rice. The characters investigated were—the golden colouring of the inner glumes with modifying factors, the shape of the rice grain, the dwarf habit in the rice plant, and the colour of rice. Mr. R. K. Bhide (*Agr. Jour. of India*, XVII, 1922, p. 524) discusses the cause of sterility in rice flowers, a phenomenon which is frequently observed in Western India.

Physiology.—The rôle of plant physiology in agriculture was dealt with by Mrs. G. L. C. Howard in the Presidential address to the Botany Section of the Lucknow meeting of the Indian Science Congress. The paper has been published in full in the *Agr. Jour. of India* (XVIII, 1923, p. 204). Major W. R. G. Atkins, has published a preliminary paper on the hydrogenioni on concentration of some Indian soils and plant juices (*Bull. 136, Agr. Research Inst., Pusa*, 1922).

Water hyacinth.—The report of the Water Hyacinth Committee of Bengal has been published. Further investigations into new methods of eradicating the pest are recommended and the need of concerted action in the future is considered essential. To ensure effective action, some form of legislation is stated to be absolutely necessary. The Committee recommended to Government " that in view of the growing menace, scientific investigations be undertaken in the first instance into the life history of the plant and its mode of propagation and later on, into the practical methods for its check and the economic utilization of hyacinth in various ways so that the cost of operations may, to a certain extent, be recovered, and for this purpose a staff consisting of the following be employed for a period of three years—(1) a plant physiologist (2) a subordinate officer of the Agricultural Department and (3) an agricultural chemist. The total cost for these need not exceed Rs. 1,000 a month."

The coconut palm.—Mr. H. C. Sampson's book on the coconut palm has appeared during the year and includes interesting and valuable results on the root system of this tree. Mr. C. X. Furtardo has published a paper on the coconut inflorescence (*Poona Agricultural College Magazine*, XIV, 1923, p. 213).

Miscellaneous.—Messrs. P. H. Carpenter and H. R. Cooper have dealt with the factors affecting the quality of tea (*Quarterly Jour., Indian Tea*

Association, 1922, p. 44). Mr. T. D. Stock has published an account (*Agr. Jour. of India*, XVII, 1922, p. 577) of a primitive form of orange cultivation in one of the Northern Shan States of Burma and has made suggestions for its improvement. Mr. G. B. Patvardhan has printed a short ecological classification of the crops of Bombay (*Poona Agr. College Mag.*, XIV, 1923, p. 194). Mr. K. Kunhikannan describes in the *Agricultural Journal of India* the introduction of a tree from the New World known as the Mesquite or Azaroba (*Prosopis juliflora*). It appears that several full grown trees already occur in India in the neighbourhood of Madras.

BOTANY

II.—ECONOMIC BOTANY

Part II.—Forest Botany

BY

R. N. PARKER, Esq., F.C.H.,

Forest Botanist.

Oecology of Sal.—Work under this head which has been in progress for many years has now reached the stage at which the Botanical Branch can leave it. The results of the small scale experiments made by Mr. Hole during past years are being used on large scale regeneration works by the Silviculturist of the United Provinces.

Systematic Botany.—No progress has been made with the study of *Dipterocarpus* as the Systematic Botanist had to cancel his tour in Tenasserim and for the time being give up all botanical work in order to devote his time to the Minor Forest Products Exhibit of the Empire Exhibition (since abandoned). The study of *Acacia* group Caesia cannot progress further for want of certain type specimens which are probably only available in the Kew Herbarium. The study of *Acacia* group Eburnea depends upon procuring of further material from S. India and although local forest officers likely to be able to assist have been addressed, so far no specimens of any *Acacia* belonging to the group have been received. Thanks to the liberality of the authorities at the Natural History Museum, Vienna, the types of several species of *Berberis* have been sent to Dehra and returned after a drawing of them had been made. There are however still several type specimens in this genus to be traced. The confusion in this genus appears to be largely due to failure to understand the species proposed by the earlier botanists such as Wallich and G. Don the types of which are all still in existence. The bamboo *Teinostachyum Helferi*, Gamble which has been flowering recently in Burma and which evidently is not a *Teinostachyum*, has now been satisfactorily placed by Mr. Gamble in a genus recently described from Cochin China and it will in future be known as **Neohauzeaua Helferi,** Gamble in Kew Bull. (1923), p. 91.

Herbarium.—5,898 sheets were added during the year which is approximately double the number added in the previous year. The increase is almost

entirely due to the taking up of collections which have been lying unnamed for years some of them since the transfer of the Saharanpur herbarium to Dehra Dun. There is now very little of this class of arrears left.

Pathology.—The most interesting discovery during the year is that the numerous *Dalbergia Sissoo* trees dying near Dehra Dun are in all probability killed by *Polyporus gilvus*. Hitherto it has always been assumed that the deaths were due to the attacks of *Fomes lucidus* as the symptoms are similar and sporophores of this fungus have been found on *Dalbergia Sissoo* near Dehra. Last autumn however, probably as a result of the very heavy monsoon, numerous sporophores of *Polyporus gilvus* were found on dead and dying *Dalbergia*, sporophores of *Fomes lucidus* being conspicuously absent on this host though common enough on *Albizzia procera*.

Miscellaneous.—An enquiry into the tanning value of the fruits of the various forms of *Terminalia Chebula* as well as of closely allied species of *Terminalia* is being carried out in conjunction with the Imperial Institute. So far the results of the analyses have not been received from London. A paper on the Tung oil trees *Aleurites Fordii* and *Aleurites montana* in India has been prepared in conjunction with the Chemical Branch of the Institute and is ready for the press.

BOTANY

II.—ECONOMIC BOTANY

Part III.—Mycology

BY

W. McRAE, M.A., B.Sc., F.L.S.,

Offg. Imperial Mycologist, Agricultural Research Institute, Pusa.

Agricultural Research Institute, Pusa.—The work on species of Piricularia on various cereals and grasses was continued but no marked results were recorded. The sclerotial fungus has been proved by infection experiments to cause a disease of the rice plant. The disease begins on the leaves gradually spreads over the plant and causes its death. The fungus sown on sugarcane gave negative results so its connection with the fungus causing a similar disease on sugarcane is still in doubt though the two fungi in this sclerotial stage appears to be the same morphologically. From the field experiments to control smut (*Tolyposporium Penicillariae*) on bajra (*Pennisetum typhoideum*) and downy mildew (*Sclerospora Maydis*) on maize no definite conclusions could be drawn as the incidence of both diseases this year was slight. This is remarkable as the monsoon was a heavy one with few breaks so that the humidity remained continuously high yet the temperatures were uniformly lower and this latter fact probably accounts for the mildness of these diseases. Of various fungi isolated from wheat plants affected by foot-rot one a species of *Helminthosporium* was shown to be able to destroy wheat seedlings. This is possibly the cause of the disease but much work still remains to be done on the other fungi invariably found associated with it on affected wheat plants. Foot-rot is said generally to be found in those fields which have been sown early so it is possible that in areas where it causes much loss if the sowing were delayed till the cold weather has really set in there would be very little trouble. The study of the genus *Helminthosporium* was continued with special reference to the relationship between species on grasses and crop plants. The two plots laid down to determine the influence of sodium sulphate applied to the soil on the growth of jute and the incidence of disease showed marked differences. That which had received applications of sodium sulphate contained 1,399 plants weighing 533 lbs. and disease was entirely absent. The other plot which had no sodium sulphate applied con-

tained 1,342 plants weighing 220 lbs. and 744 of them were diseased. So promising is this result that a more extensive series of field experiments were laid down to test the accuracy and applicability of this treatment. The influence of the composition of the soil upon the incidence of disease in jute is being studied in cultures designed to test the effect of certain constituents of the soil on the growth of the fungus in culture. From members of the *Cucurbitaceae* that are grown as vegetables and that were rotting in considerable numbers strains of *Pythium* were isolated. The morphology of those from *Luffa acutangula L. aegyptiaca, Trichosanthes anguina* and *Lagenaria vulgaris* was studied.

The wilt caused by *Fusarium udum* on pigeon pea (*Cajanus indicus*) was severe this season. In the permanent manurial series of experiments the number of wilted plants has been recorded in three seasons in each of the two series. The averages of each of the three plots that receive superphosphate are—

4, 7·5 and 4 times in A series } the average of the 5 plots that get
6, 4·0 and 4 times in B series } no phosphate.

The averages of each of the 3 cattle manure plots are—

2, 2½ and 2 times in A series } the average of the 5 plots that get no
1, 1 and 2 times in B series } phosphate.

The averages of each of the green manure plot are—

·36, ·23 and ·15 times in A series } the average of the 5 plots that get
·32, ·64 and ·23 times in B series } no phosphate.

It appears that those plots that get superphosphate carry an increased number of wilted plants that is significant and that the green manure plot has so small a number as to be significant. The cattle manure plots receive small but increasing doses from plot to plot and the number of wilted plants is highest in the plot that gets the largest dose yet the numbers of wilted plants are not so different as to appear to have significants beyond indicating a possible tendency that could be tested on plots that receive larger quantities of cattle manure. The fact that in the green manure plots to which superphosphate had been added the numbers of wilted plants are slightly higher than in the plots that get no phosphate seems to indicate that the superphosphate neutralises the depressing influence of the green manure on the incidence of the disease. Experiments are in progress to elucidate the effect of phosphate on the plant and the fungus and the effect of mineral phosphate as compared with phosphate in association with organic matter in cattle and green manure. This subject is of importance inasmuch as green manure associated with superphosphate increases the yield of other crops on the alluvium and that pigeon-pea is one of the crops in the usual rotation.

Madras.—Work on the following subjects was in progress. Diseases caused by species of *Vermicularia* on turmeric (*Curcuma longa*) cabbage and Bengal gram (*Circer arietinum*). Spores of *Vermicularia curcumae* were found to germinate after seven months and they are capable of infecting

cabbage, brinjal, *Datura*, knolkohl and *Withania somnifera*. Sclerotial masses were found on the rhizomes of turmeric especially on and near the scaly leaves and it is probably by means of these that the disease is carried from crop to crop. These sclerotia are capable of germination up to two years. The species of Vermicularia on cabbage was found to infect chilli, brinjal, ginger and Datura. That on Bengal gram and another on vegetable marrow are under study. Among new varieties of cane 15 of the cross between Kassoer and D 74 and 9 of the cross between Kassoer and Fiji B have proved so far resistant to smut. Soil infected with spores of *Sclerospora graminicola*, leaf shredding disease of *Andropogon Sorghum*, produced a crop of diseased plants indicating the means by which the disease is carried over. *Rhizoctonia* and *Gloeosporium* on *Carica papaya* are being studied and the latter is effectively checked by spraying with Bordeaux mixture. *Gloeosporium* on mango, and species of *Cercospora* on safflower, fenugreek, brinjal, pomegranate and *Solanum nigrum* were being studied. A systematic study of the *Diplodias* of South India has been made and a paper sent for publication. Spraying on a large scale was done on grape vines against mildew, on areca-nuts against *Phytophathora arecae*, on coffee against leaf-disease and black-rot, on turmeric against *Vermicularia curcumae* and on citrus against scab. In the areca gardens on the west coast Coconut trees that were dropping their nuts were found to be infected with *Phytophthora arecae*, the fungus that causes the rotting of areca-nuts. Infection experiments with pure cultures produced the same symptoms. Spraying the bunches of coconuts at the time of spraying the areca-nuts is being tried as a preventive. On the potato farm near Ootacamund 2,409 maunds of potatoes comprising 15 varieties were examined in order to select for planting good seed free from signs of fungus infection.

Manurial experiments against root diseases of tea caused by *Rosellinia arcuata* and *Hymenochaeta noxia* are being carried out and also spraying experiments on coffee against leaf disease (*Hemileia vastartrix*) and die-back, due to or associated with *Colletotrichum coffeanum* which usually is found along with leaf fall. On the unsprayed plots the ground was strewn with fallen leaves which invariably showed the disease. By shaking the bushes numbers of leaves dropped and many of the twigs were drying up. On the sprayed plots the bushes were well covered with leaves and the leaves remained on the bushes while there was very little die-back. This applied to both flushes of leaves. There is no doubt about spraying doing a great deal of good. Various sprays and different concentrations were used. This experiment will be repeated several times both with liquid and dust sprays to find the best and most economical method of carrying out the work in the conditions of the coffee districts.

Bombay.—The investigation of the storage rots of potatoes was continued and the Assistant Professor of Mycology visited Italy the principal source of seed supply for the Bombay Presidency to study the potato industry with a view to submit proposals for the improvement of the crop in the Presidency. The results of last year's work on the potato rots have been written up in 3 papers submitted for publication. A description of the four most common

potato rot fungi (two species of Fusarium, *Sclerotium Rolfsii*, and a species of Sclerotium) has been prepared and their temperature relationship studied. The work on cotton wilt with a view to discover or evolve a resistant variety has been carried a step further. Inoculations were made in the field and in pots. Of 431 plants of Wagale 4 per cent. were wilted, of 414 plants of Dharwar 2, 30 per cent. and of 419 plants of Kumta 39 per cent. The other varieties tried varied from 56 to 83 per cent. Wagale has withstood the attack remarkably well as it did last year. The experiment indicates that Kumta cotton contains types which resist wilt better than Dharwar 2, accordingly a number of resistant plants of this variety have been selected to test this. It was found that in the first generation of the cross between Dharwar 1 and a pure wilt resistant strain of Wagale resistance is dominant, at least during the greater part of the growing period. In pot experiments it was shown that the variety Broach Deshi Plant 6 is completely immune to wilt.

The leaf spot and blight of onions was found by infection experiments to be caused by a species of *Alternaria* which is a wound parasite. High temperature and humidity were found to be necessary for the spread of the disease. Field experiments showed that Goa and Nandore varieties of onions resist the disease to a considerable extent. The application of sodium nitrate in small doses at intervals combined with " rabbing " appears to be beneficial to the crop but Burgundy mixture had no effect in checking the disease.

The study of the mango inflorescence blight has shown that, though hoppers are the constantly associated with the blight, a mildew is also concerned. Preliminary observations made in the important mango tracts indicate that mildew is as important as the hoppers and in some cases it is the sole cause of the blight. Operations against the disease are to be started in the coming season.

Data are being collected on the diseases grouped under the term mosaic of which examples in Bombay are found on cardamoms, chilli, tobacco, potato, tomato, and *Raphanus sativus var. candatus*.

A disease of wheat associated with an alternaria and one of the betel vine associated with a Fusarium were under study.

Field experiments carried over several years have shown that smut (*Ustilago Eleusinis* Kulk.) of *Eleusine Coracana* is not seed-borne and that seed-treatment with copper sulphate is of no use. The results of spraying experiments against mildew on Cuminum were inconclusive as no disease appeared on the crop. The spraying campaign against Koleroga (*Phytophthora arecae*) was continued.

Bengal.—Several fungi associated with a disease of betel-vine have been isolated and their morphology studied. A bud rot of the areca palm was investigated but its cause is still obscure. Spraying was done against *Phomopsis vexans* on brinjal and against damping off on tobacco seedlings.

Central Provinces.—The efficacy of different preventive treatments against jowar smut was tested. The dusting method which appeared most

successful was that with copper carbonate dust. But the practical difficulty in the way of treating large quantities of seed with this dust was the want of a good type of a mixing machine. Lime sulphur and flowers of sulphur also were found to be effective. Of the steeping methods copper sulphate solution was found to be most effective. Formalin was found to be very inferior. Some work on cotton wilt was also done. Inoculations with cultures of *Fusaria* and *Cephalosporia* isolated from wilted cotton stems and roots invariably failed.

Assam.—Data with regard to the prevalence of a bud-rot of areca palms was collected and routine spraying was done on potatoes on the Shillong farm. Experiments were begun with a view to find a preventive for a disease caused by a species of Cephalosporium on rice plants. The soil was treated with various fertilisers and the seed with 3 per cent. formalin.

Indian Tea Association.—Some observations were made on the effect of various kinds of plucking on the susceptibility of the tea plant to attack of *Pestalozzia Theae Laestadia camelliae* and *Glomerella cingulata*. It was found that the more leaf taken off the plant the greater the susceptibility to these diseases. The life histories of a number of unnamed fungi recently found on diseased tea plants were worked out.

Most of the time was devoted to further experiments on the micro-organisms present in fermenting tea and considerable progress was made. Over fifty yeasts and a number of bacteria are under investigation.

United Provinces.—Work on the storage rots and field diseases of potato was continued. Very satisfactory results were obtained in experiments on storing seed and food potatoes at low temperature. Mosaic disease is found to occur widely, in considerable amount, in some districts the percentage being as much as 5 per cent. This disease greatly reduces the crop yield and is to a large extent responsible for the deterioration of the potato crop.

A serious nematode disease of wheat occurred in various parts of the province. This disease is under investigation. Work on the wilt disease of safflower was concluded and will shortly be published.

AGRICULTURAL BACTERIOLOGY

BY

C. M. HUTCHINSON, C.I.E., B.A.

Imperial Agricultural Bacteriologist.

WORK AT PUSA.

Soil Biology.

Nitrogen Fixation in soil by "Non Symbiotic" organisms.—The work on this subject previously reported was continued and the following experiments were carried out :—

I. A large number of experiments was carried out to obtain further information as to the symbiotic relationship between algæ and nitrogen fixing soil organisms. Large differences in fixation were found to occur as the result of the influence of light and darkness upon algal growth ; thus in three months January to April the nitrogen fixed by a mixed culture of algæ and soil organisms was 1·19 mgms. in the dark and 3·50 mgms. in the light ; a second series run from 2nd July to 1st August gave 2·55 mgms. Nitrogen in the dark and 9·6 mgms. Nitrogen in the light.

Fermented residues of a green manure crop *Crotalaria juncea* were used to replace mannite as a source of energy in a pure culture of azotobacter ; 2 gms. of this material gave a fixation of 1·4 mgms. Nitrogen in 24 days 4th July to 28th July 1922. This would correspond in the field to a fixation of about 1·5 lbs. nitrogen to the ton of green manure in three weeks' time. Other experiments were made using a variety of cellulose decomposition products.

II. The effect of various organic residues and compounds upon nitrogen fixation in the soil.

Various green manures and crop residues were experimented with and large differences were noted in their suitability as sources of energy for nitrogen fixation by soil organisms ; thus Bajra (*Sorghum halepense*) gave 33·96 mgms. of added nitrogen whilst cowpea gave 12·03 mgms. and Asoka (*Polyaltha longifolia* leaves gave only 5·32 mgms. over a period of 3 months. These amounts were greatly increased by the introduction of fermenting organisms in the form of watery extract of cow manure. Previous fermentation of the organic residues considerably increased their apparent value as sources of energy for azotobacter and optimal periods of fermentation were found which varied with different materials. Thus maize which unfermented helped to fix 27 mgms. when fermented for one month before adding it to the soil, gave a nitrogen increase of 47 mgms. which was reduced to 34 mgms. when

fermentation had been continued for three months. Similarly fermented straw gave 19·3 mgms. Nitrogen as against 9·25 mgms. Nitrogen fixed in soil by unfermented straw over a 3 months' period.

III. Nitrogen fixation was found to occur in cowdung alone, and to be increased by some 15 per cent. by the addition of straw. Fixation also took place in a mixture of straw 15 gms. with 20 c. c. of a water extract of cowdung (1 gm. in 50 c. c.).

IV. Fixation of nitrogen in pure cultures of azotobacter was increased by small additions of nitrate; (5 mgms. per 100 c. c. of culture solution) larger amounts inhibited fixation completely and resulted in reduction of the added nitrate. Artificial æration (by aspirated air) increased the amount of fixation from 8 mgms. to 9 mgms. per gram of mannite and at the same time greatly increased the growth of azotobacter.

Experiments were made to determine the relative rates of utilization of dextrose by various nitrogen fixing organisms, azotobacter, clostridium, B. radicicola and a mixed culture from cow manure, in liquid culture. The results are shown in the accompanying graph.

The effect of an indigenous rock phosphate on nitrogen fixation in pure culture by azotobacter was compared with that of Basic Slag; the former had a distinct depressive action whereas Slag has a decidedly beneficial effect.

V. Nitrogen fixation was found to be active in river silt and a vigorous growth of algæ occurred in this medium in diffused light. More than double the quantity of nitrogen was fixed in the light than when the silt was kept in darkness (17·3 mgms. and 8·2 mgms. per 100 gms. silt) thus affording further evidence of the symbiotic relationship existing between the algal growth and that of azotobacter. Addition of mannite added some 4 mgms. Nitrogen to the amount fixed without it.

Eight varieties of algæ, distinguished by morphological characters under microscopic examination, were tested in pure cultures in symbiosis with azotobacter and gave varying results some negative (3) and some positive increases from 0·48 mgms. to 2·4 mgms. Nitrogen above the controls. In a rich garden soil showing algal growth the amounts of nitrogen fixed in four months were. In darkness 54 mgms. In light 77 mgms. With nitrate (5 mgms. per 100 gms. soil) in Light 91 mgms. per 100 gms. soil. Artificial æration in culture solutions containing algæ and azotobacter was found to depress nitrogen fixation to a considerable extent.

VI. Field experiments to determine the effect of various manurial and other treatments were commenced; the results will be reported later.

The facts above recorded, although forming no doubt but a fraction of the greater mass of information which will be necessary for any adequate understanding of this important subject yet serve to indicate not only that progress is being made in the right direction, but that the possibilities connected with solution of the problem are fully as great as they appeared when that problem was first attacked. Briefly we know by observation that large amounts of

nitrogen can be added to Indian field soils by asymbiotic organisms, but nothing was known as to the causes responsible for the very wide variations in this amount in the same soils from year to year. The hopeful features of our results are that we have been able to obtain and establish similar variations under known and controlled conditions these latter not involving the utilization of economically impossible sources of energy such as sugar or molasses, but taking advantage of our previous work on fermentation of organic residues and thus relying on indigenous raw material alone. The symbiotic relationships with algæ are naturally of extraordinary interest in this country where these organisms are present in every soil, and it can be only a matter of time and further research along the right lines before we are able to indicate in what manner the management of the soil may be modified so as to increase the amount and rate of nitrogen fixation naturally taking place therein.

Nitrification.—Further work on the activation of nitrification of cattle urine was carried out with a view to conservation of its nitrogen content. A method of doing this, suitable for use by the ordinary Indian cattle owner, was worked out, consisting essentially of the use of a suitably prepared ærating filter bed made of broken brick or rubble, the passage of the collected and diluted urine through this bed resulting in the formation of nitrates and recovery of the major portion of the original Nitrogen content of the urine in this form.

The effect of composting with phosphates and sulphur upon the nitrification of various refractory sources of organic nitrogen such as Mahua cake (*Bassia latifolia*) was further studied in relation to the problem of solubilization of mineral phosphates by the same means. The general conclusion arrived at as a result of these experiments, in continuation of those of previous years, was that it is highly advantageous when dealing with the problem of the use of organic manures and residues, to make use of the method of fermentation under controlled conditions, already worked out at Pusa and recommended in the case of green manures.

The formation of nitrates and their vertical and horizontal distribution in soils under varying conditions of cropping and cultivation was further studied in field plots.

Green Manuring.—The results of the green manuring experiments on the Punjab Experimental area of the farm were made the subject of paper in the Indian Journal of Agriculture. The continued residual effect of large applications of fermented green manure was a marked feature of the returns and the effectiveness of such applications in conjunction with the use of superphosphate was also most noticeable. The most remarkable result, however, was that obtained by a putting in a fresh crop of green manure (*Crotalaria Juncea*) over the whole area five years after application of the original manurial and other differential treatment. The application of this green manure gave an immediate increase in the succeeding cold weather cereal crop over the whole of the plots, but the remarkable feature of the

returns was the obvious persistence of the effect of the original applications of superphosphate on certain plots, although these were made five years before. The underlying causes are naturally obscure but the importance of the result from an economic point of view alone, has led to the initiation of experiments designed to throw light on this interesting problem, with special reference to the possibility of bacterial intervention playing a considerable part in the matter. A field scale experiment confirmed the conclusions drawn from small plots in the previous season that in using Sannai (Crotalaria juncea) as a green manure it might be advantageous to combine with this operation the separation of the stems as a source of fibre, the tops and leaves alone being buried in the soil. The green manure effect of such separation on the following *rabi* crop was found in some cases to be better and in all cases to be at least equal to that of the whole plant.

Bacterial decomposition of Organic residues.—Further study of this subject with special reference to Cellulose led to the isolation of a specific organism capable of dissolving cellulose under ærobic conditions but only in symbiosis with certain other soil bacteria of which several were found. None of these secondary organisms had any capacity for cellulose destruction either individually or in symbiosis with any other except the specific one first mentioned. The characters and relationships of these organisms will form the subject of a paper to be published in due course.

Solubilization of Mineral Phosphates.—Further work was done on this subject in view of the importance of bringing into use the large, but at present scarcely touched supplies of indigenous phosphates in this country.

By the use of cultures of sulphur oxidizing bacteria, these being watered into composts containing rock phosphate and sulphur, very great advances were made in the percentage of phosphate rendered soluble. In the previous report it was shown that by composting phosphate, cake, and sulphur, some 4·3 per cent. of phosphate was solubilized in sixteen weeks. By the addition of bacterial cultures this amount was increased to 66·9 per cent. with one culture and to 88·9 per cent. with another, in a period of only ten weeks. These results were obtained with indigenous rock phosphates; the same cultures acting on pure tricalcic phosphate solubilized 65 per cent. and 95·9 per cent. respectively. An interesting observation was made as to the beneficial effect of additions of gypsum to the sulphur phosphate compost. Such additions appeared to increase solubilization by improving the physical texture of the mass with regard to æration, this latter condition being a vital factor in oxidation of sulphur by bacterial action. A paper on this subject was written for the Indian Journal of Agriculture.

Indigo.—Work on this subject was necessarily curtailed as a result of the death of the Assistant Bacteriologist Mr. Petty who had been specially recruited to deal with industrial research problems.

Experiments on the use of pure cultures of indican hydrolyzing bacteria on a factory scale demonstrated the necessity of further work to ascertain the best methods of establishing such bacteria in the indigo vats in a concen-

tration sufficient to secure the preponderance of their action over that of adventitious organisms unavoidably introduced with the water or the plant itself. In view of the closing down of the Indigo Chemist's Section and the abolition of the post-of assistant bacteriologist in this section work on this subject must necessarily be relegated to a subordinate position. Some interesting observations were made on the losses occurring between steeping and beating; it was found that an interval of at least one hour may be allowed without appreciable deterioration or loss. A series of experiments on the neutralization of the fermented liquor with caustic soda before beating gave results which led to definite conclusions of practical value. In cases where fermentation and settling are normal no advantage is to be obtained by the use of soda; when, however, fermentation is poor, settling bad, and produce low, neutralization with caustic soda may be recommended as likely to result in improved settling and increased yield of indigo. The results of these experiments are detailed in an Indigo Publication now in the Press.

A considerable amount of work was done on the subject of sterilization of Indigo paste. Numerous bacteria were isolated from paste in a fermenting condition, some samples of which had been imperfectly sterilized in England with paranitranilin and others by heat. The thermal death point of these was determined and recommendations as to appropriate methods of sterilization by heat were made.

Bacterial infection of Sugar Mills.—Investigations were made of the character and specific action of various organisms found as contaminations in the cane juice of Sugar Mills in Bihar. A constant small percentage loss of sugar occurs in the mill, part of which is probably due to inversion during the short time of passage from the rollers to the evaporating plant. Although a large number of organisms was found, only a few of these possessed any considerable inverting power, and further work will be required to determine the practical significance of their presence in the cane juice in the mill. It appears probable, however, that some degree of antiseptic precaution in the mill would be attended with advantages.

E. C.—Further work on this antiseptic has now led to the standardization of a type of electrolytic apparatus specially designed for its preparation and made by Messrs. Mather & Platt of Manchester. This apparatus is specially designed for use in hospitals and can be run on an ordinary lighting circuit without any expert knowledge. As this preparation has a carbolic co-efficient of 3·9 and is made from entirely indigenous materials at a very low cost its use should allow of great savings in outlay on antiseptics whether for hospital or other purposes, and especially for sterilization of water as a preventive measure against cholera.

I read a paper on this subject before the Medical Section of the Indian Science Congress at Lucknow. Arrangements were completed to supply the Government of Bihar and Orissa with sufficient quantities of E. C. to meet the requirements of five of the principal hospitals in that Province until such time as these institutions should be in a position to produce their own supplies.

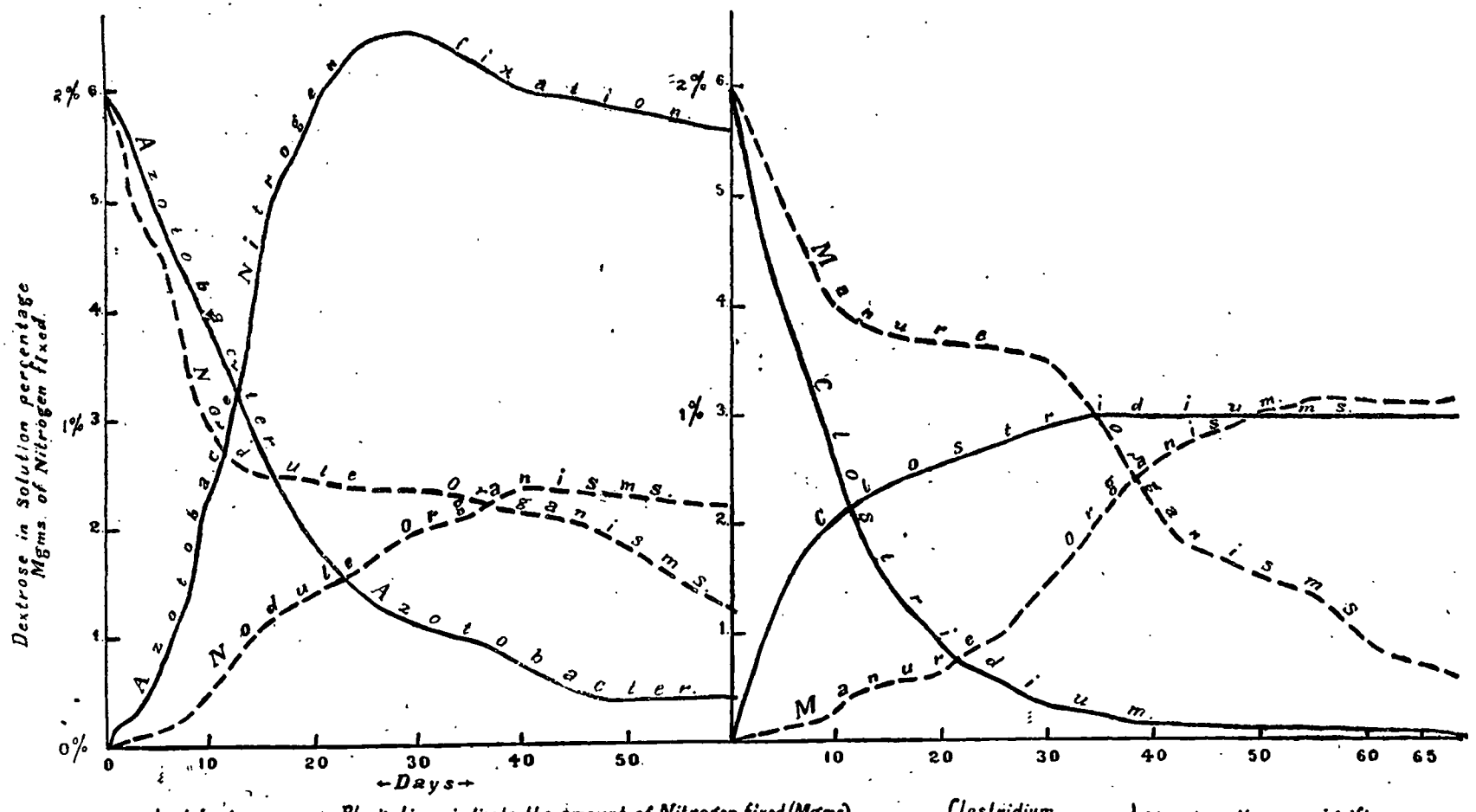
Dextrose in solution percentage
Mgms. of Nitrogen fixed.
2%
1%
0%
Azotobacter Nodule organisms.
Nitrogen fixation.
Azotobacter Nodule organisms.
Azotobacter.
Manure
Clostridium
Clostridium
Manure organisms.
Manure organisms.
Manure.
10
20
30
40
50
60
65
←Days→
Azotobacter Nodule organisms.
Black Lines indicate the amount of Nitrogen fixed (Mgms).
Red Lines Dextrose in solution (%)
Clostridium Manure organisms.
Lines have the same significance.

PLATE I.

The appointment of special officer to take charge of this production for the Province has been sanctioned by the Local Government.

Work in the Provinces.

Madras.—The premature fall of cotton bolls was found to be due to a rotting bacterium which was isolated and cultured. It is thought that inoculation occurs naturally through the intervention of two species of *Capsids*, and that the use of insecticides might be required to avert this.

Nitrogen fixing organisms were isolated from the nodular growths on the leaves of *Chomelia asiatica* and *Pavetta indica*; it is suggested that these plants would therefore be appropriate for use as green manure.

Megasse was shown to form a suitable medium for supplying energy to non-symbiotic nitrogen fixing organisms.

The malting properties of *Cholam* (*Andropogon Sorghum*) were examined and found to compare favourably with those of barley, maltose being the final product; proportionately large amounts of dextrine are formed in the case of *Cholam*. The differences observed support the suggestion that hydrolysis of starch in malting is brought about by two enzymes an "amylase" and a "dextrinase."

Central Provinces.—Attention has been principally directed to the practical application of biological analysis of soils to ascertaining the manurial requirements of selected types in the Province as judged by their specific biological reactions with various indigenous organic manures. This method gives valuable information of a practical nature.

FORESTRY

Part I.—Silviculture

BY

S. H. HOWARD, B.A.

Silviculturist.

During the year under report the work of the branch could not be carried out on the lines recommended by the Silvicultural Conference of 1922 owing to the extreme shortage of staff and lack of money. It is hoped that this will be rectified in the near future but meanwhile new working plans are being made and old ones revised which perforce have to be based on data very little better than that on which the first plans were made. When such data are actually available, or are so nearly available that it requires very little work to fill the existing gaps, it seems a great pity that lack of staff to compile these results into a form in which they can be made use of, should necessitate important working plans being based on imperfect data.

Statistical work.—A very large number of plots have been measured by the various local silviculturists and the Central Institute and all results sent to Dehra Dun for working out. The United Provinces have helped greatly in working out many of their own results.

The most important matter during the year, however, is the compilation of the data for *Shorea robusta* (*sal*) into a yield table of three quality classes. This became an absolute necessity owing to the number of working plans for this species coming under revision in the United Provinces. The table has fundamentally changed the management and rendered possible a very large and perpetual increase in revenue estimated at 10 lakhs of rupees per annum by the Conservator of Forests, Working Plan Circle, United Provinces. The table applies to the United Provinces but will be applicable to other *sal* areas.

Volume and form factor tables and a general yield table for *sal* for other provinces will be undertaken during the forthcoming year.

The table is imperfect owing to the artificial timber limits necessary for such a compilation for such a country as India but it is hoped that within a very short time the outturn under practical conditions will be available. The table which at present is principally for Working Plan officers will then be of real help to the ordinary Divisional Forest Officer.

The other statistical work done on various other species has advanced to the stage that, given the necessary staff, yield and volume tables will be published in the forthcoming year for at least two more species.

The Sal (*Shorea robusta*).—Except in the matter of statistics the Central Institute has done little concerning this species as all such experimental work outside the seedling stage is now taken over by the provinces. Further experiments in the matter of keeping the seed till the break of the rains give promise of success. A natural regeneration experiment shows that a sheltorewod is probably essential in frost localities.

In the provinces natural and artificial work continues. The artificial regeneration of *sal* in suitable areas is a solved problem wherever labour can be obtained and where rain can be reckoned on at the time of seed ripening. Natural regeneration from seed is still largely unsolved though knowledge has advanced.

Afforestation.—The experiments in Zabarkhet have yielded results which are now almost conclusive. The problem is to afforest a blank in a *sal* forest with heavy grass and frost in winter *with no tending whatever during the rains* : with tending the problem would be simple.

The solutions in such a neighbourhood as Dehra Dun are : (1) Sow *chir* pine (*Pinus longifolia*) in lines ploughed through the grass 5 ft. or 6 ft. apart at the beginning of the rains. The seed should be red leaded before sowing. No further attention is necessary that year but a resowing may be necessary the following rains. During the winter the grass should be cut between the *chir* lines. The plants will in three or four years be about 4 ft. high. (2) Plant root and shoot pruned transplants of sissoo in holes 6 ft. by 6 ft. at the beginning of the rains. These pruned transplants should have a stem 2″ to 4″ long and root say 8″ to 10″. They will grow through despite the grass.

Either species is good but the *sissoo* suffers more from frost than the *chir* and on the whole the *chir* is preferable. Such afforestation areas must be fenced if there is much game. Pigs and porcupines do the most damage.

Experimental silviculture.—Work was continued on the weight of seeds and the results will be incorporated in the already existing bulletin on this subject.

A great deal of work was done on artificial regeneration with various species both entire and pruned transplants being tested, rains and winter transplanting and weeding versus non-weeding in each case. It is impossible to go into all the details and equally impossible to give general rules to which there are not many exceptions. Moreover the experiments are not by any means complete. Still the following are generally correct remarks in the case of the majority of the species tried.

Almost every species under whatever method or time of transplanting benefits greatly by weeding. In most cases weeding is essential to success.

Winter transplanting was almost always a failure whether weeded or not but even where a percentage of success was obtained it is very inferior to the ordinary transplanting at the beginning of the rains.

The results of entire transplants as compared with root and shoot cuttings are not complete. At present it appears that some species do better one way some another.

Some species are hard to transplant by any method.

Experiments were continued with bamboo regeneration (*Dendrocalamus strictus*). It was conclusively proved that a sure method is to plant offsets from one or two year old culms with rhizome attached and a well developed bud. These planted at the break of the rains gave 100 per cent. success and had culms 24 ft. long after two years.

The camphor work is completed and has been sent to press as a forest record though not actually published till after the close of the year.

FORESTRY

Part II.—Economic Forest Products

BY

R. S. PEARSON, C.I.E.,

Forest Economist.

1. **General Work of Administration.**—The year 1922-23 has been one of rapid expansion on the lines laid down in the last year's report, and although the activities of the Branch were much curtailed owing to financial stringency, nevertheless progress has been satisfactory.

The Forest Economist had the major portion of his time taken up in organising and controlling the erection of the plant at the New Site, and at the close of the year under review the Sawmill, Wood Preservation Plant and Seasoning Kilns were practically completed; the Paper Pulp Plant and the Veneer Section were well on their way to completion; while some of the Timber Testing Machines were erected and others were working in a temporary workshop.

The financial condition of the country reacted, as everywhere, on the Economic Branch; and although much has been done there is no doubt that had Imperial and Upper Grade Assistants been appointed to the Sectional Officers, to be trained under their expert supervision, the results would have been considerably better.

The Forest Economist's touring was restricted, due to the continual supervision work at Dehra, to a visit to Calcutta in connection with the Exhibition of 1924; and to inspecting some experimental sleepers near Hardwar. Mr. Jollye, who held the appointment of Assistant Forest Economist until October 1922, when he went on leave and was replaced by Mr. Trotter, inspected the experimental sleepers on the Itarsi-Betul Section.

Year by year the number of enquiries increases both from Forest Officers, the Railways, Ordnance and Army Departments, Public Works, Commercial firms and private persons, so that the position now is that the staff, as at present constituted, cannot adequately cope with the work. When the Imperial and Upper Grade Assistants have been appointed, and the new Laboratories and Workshops are in full running order, this difficulty should be overcome.

The Trade Supplement to the "Indian Forester" which was started last year, has proved a greater success than was anticipated. It has now been enlarged and will gradually be developed.

II.—Experimental and Commercial Activities.

1. **Section of Wood Technology.**—The Wood Technologist, Dr. H. P. Brown, who came to the Institute for 22 months from Syracuse University just before the commencement of the year under report, has laid a fine foundation for the work of this section, which may be divided into two heads ; namely, routine and research work. Under routine work may be mentioned the identification of timbers. We receive constantly specimens of timbers for identifications, either in connection with a special enquiry from the provinces, or from commercial concerns, the railways and not infrequently for legal cases. The other portion of routine work consists in consulting with the other specialists on the staff as to properties of woods for a stated purpose which are best determined from their anatomical structure

The Research work in hand comprises :—

I. The preparation of keys for the determination of timber specimens in the field based on macroscopical features, as seen under a pocket lens.

II. The same, based on microscopical characters for critical determination in the laboratory.

III. The preparation of a syllabus for use in teaching wood anatomy to the Provincial Class Students.

The progress made is that the routine work has been kept up to date : on the research side, mounts for microscopical work and photo micrographs have been prepared for approximately 175 species of timber. These latter consist of cross, tangential and radial microsections, of which photographs have been prepared for all the cross sections and 60 of the tangential sections at a 380 magnification. Another 125 species are in preparation for sectioning. No low power sections have as yet been prepared, but this side of the work will be started as soon as the hot weather begins, when photography will be held temporarily in abeyance till the rains break.

2. **Section of Timber Seasoning.**—The buildings for the experimental seasoning kilns at the new site have been practically completed, and the installation of the mechanical equipment has progressed to such a point that the kilns are ready to operate as soon as steam and water are available.

The experiments which had been under way for three years in connection with the air-seasoning of 53 important species of timber in different parts of India have been concluded, and the results have been published in " Indian Forest Records, Vol. IX, Part V." " Further experiments in the Air Seasoning of Indian Timbers and General Recommendations as to Seasoning Methods," by Mr. C. V. Sweet, Officer in Charge, Seasoning, with a chapter on "Damage to Timber by Insects " by Dr. C. F. C. Beeson.

An air-seasoning experiment on a commercial scale has been started in the Government Agent's timber depot in Calcutta, with eight important timbers from Bengal and the Andamans to determine (*a*) the length of time required for the air-seasoning of various timbers under moist climate conditions and (*b*) the amount of depreciation due to cracking, splitting, staining,

etc. Definite figures as to these items are totally lacking for Indian timbers, but are of primary importance in determining the relative economy of kiln and air-seasoning. Figures pertaining to kiln-seasoning will be accumulated at Dehra Dun when the experimental kilns are in operation.

A comprehensive scheme has been outlined by Mr. C. V. Sweet, Officer in charge Seasoning, and experiments initiated, to determine for the Government Gun Carriage Factory at Jubbulpore the most economical procedure to follow in the seasoning of their timber. The experiments are being carried out with the object of determining to what extent their present practice may be improved either by remodelling their present timber-seasoning godowns or by installing seasoning kilns. Figures are being accumulated to show which method of seasoning is most economical. The work at Jubbulpore affords an opportunity to accumulate data which can be got in no other way and which will be of general value to the Institute.

As a part of the general scheme a shipment of 3½ inch Sisso (*Dalbergia Sissoo*) planks and felloes was sent to Dehra Dun for kiln-seasoning. The timber was kiln-seasoned in two months' time to a point of equilibrium with the dry climate conditions of the Central Provinces with practically no loss whatever due to cracking, splitting, etc. In the past similar timber has been air-seasoned at the Gun Carriage Factory from 4 to 5 years, according to the present system; and there has been considerable loss at the end of that time due to splitting. The very marked reduction in the seasoning time by kiln-seasoning will reduce their capital outlay in timber by lakhs of rupees.

An illustrated lecture on the importance of the economic value of timber-seasoning was given by the Seasoning Officer in the Indian Museum, Calcutta, under the auspices of the Bengal Chamber of Commerce and the Director of Industries. The timber firms of Calcutta were well represented at the lecture, and it is thought that the occasion served to awaken considerable interest in the work that is being started at Dehra Dun along this line.

Probably the most important factor governing the introduction of new species of Indian timbers into the market is the question of proper seasoning and grading. The suppliers and users of timber are reluctantly being forced to recognise the importance of adopting correct methods of seasoning their timbers by repeated failure and loss of trade. This being the case it is imperative that this section of our work be developed to the utmost. It is satisfactory to note therefore that this section has done most excellent work throughout the year under report and that we are now well on the way to tackling the most important of all utilisation problems, namely the proper seasoning of timbers in India.

The Seasoning Officer went to Rangoon to confer with the Seasoning Officer in Burma regarding the co-ordination of work and particularly the adoption of uniform grading rules to be used in judging the results of seasoning experiments.

3. **Section of Timber Testing.**—The four testing machines erected in the temporary workshops were in operation throughout the year, and the

work according to Project 1 which was prepared and sanctioned last year was taken up. Project No. 0, which comprises all special enquiries, such as spike-pulling tests on sleeper woods, impact and static bending tests on tool handles, etc., was also in force, and valuable data accumulated bearing on the various subjects. The foundations for all machines were put into the New Testing Shops, and two machines erected. As soon as the electrical scheme is put through the machines now in the temporary workshops will be taken down and re-erected at the new site.

The importance of timber testing may be gauged by enquiries made by persons and bodies with widely different interests and spheres of action. Thus Mr. Seaman, Officer in charge Timber-Testing, was entrusted with the work of rewriting the portion pertaining to timber of the Military Works Handbook, and submitted a list of grading rules and tables of working stresses to the Punjab Public Works Department. Similar information was supplied to the Superintendent of Workshops, Sarda Canal, to the State Engineer, Mayurbhanj, to the Bridge Department, Great Indian Peninsula Railway and to the Executive Engineer, Saharanpur. Tests were carried out on behalf of the Burma Railways, to determine the best size hole to bore in Pyinkado sleepers (*Xylia dolabriformis*) for spike-driving while bending tests on bamboo lance-shafts were carried out for the Inspector of Guns and Rifles, Ishapur. A long series of tests were carried out to find substitutes for hickory for oil-well sucker rods, and definite and satisfactory results obtained and submitted to the Indian Oil Companies concerned. Tests on hammer handles were carried out for the Government Wood Working Institute, Bareilly, and a further supply of new timbers has been received with a request that similar tests be carried out. A number of reports were prepared, the most important of which is an Interim Report on all results obtained under Projects No. 1 and No. 0, which is now in the press.

The total number of tests carried out during the year was as follows :—

	Mechanical.	Physical.	Total.
Project No. 0	3,012	1,804	4,816
„ „ 1	2,795	3,667	6,462
TOTAL .	5,807	5,471	11,278

Routine tests according to Project No. 1 involving tests on green air-dried and kiln-dried specimens were carried out on Teak from Burma and the Central Provinces, on Sain (*Terminalia tomentosa*), Kanyin (*Dipterocarpus alatus*), Gurjan (*Dipterocarpus turbinatus*), In (*Dipterocarpus tuberculatus*), Deodar (*Cedrus Libani* Var. *Deodara*); and tests on green material only on Bakli (*Anogeissus latifolia*).

Tests according to Project No. 0 comprised :—

1. The completion of preliminary tests on Sucker rods.

2. The completion of preliminary tests on plugs for Stent concrete sleepers.

3. A series of spike-pulling tests on railway sleepers.

4. Impact tests on hammer and implement handles.

5. Comparative tests along routine lines of *Frenela rhomboidea, Eucalyptus globulus, Cullenia excelsa, Cupressus torulosa, Kayea assamica, Lagerstroemia tomentosa Pentace burmanica, Cupressus macrocarpa* and *Cryptomeria japonica.*

During the year a new type of spike-pulling meter and a modified type of compressometer were designed by the Timber Testing Officer. The former has only been calibrated and not yet tested, while the latter after calibration has been put in use and found to be most satisfactory.

4. **Section of Minor Forest Products.**—The scheme to establish an industry in *Boswellia serrata* gum oleo-resin in the Bombay Presidency is still under consideration, and the work in this connection is being actively prosecuted. The up-to-date steam distillation plant for producing "Rosha oil" from *Cymbopogon martinii* grass in the Central Provinces, which was erected 2 or 3 years ago, has proved a success and may now be considered an established fact.

It is to be hoped that the appointment of an Officer to take charge of the office of Minor Forest Products will not be indefinitely postponed, as a richer field for enquiry and one more likely to yield sound commercial results would be difficult to find.

5. **Section of Wood Utilisation.**—Owing to the Seasoning Kilns, Wood Workshops and Testing Laboratories not being in full working order and the veneer plant not being erected, the number of experiments carried out was restricted to those which could be dealt with in the Testing Laboratories and by sending the timber elsewhere to be dealt with. The rough-cut specimens to be tested for bobbins by a large manufacturing firm in England have been reported on, and generally speaking the results are not encouraging. The report, however, has not yet been fully considered, as it has only recently been received. The tests carried out to find woods suitable for sucker-rods definitely showed that *Terminalia tomentosa* and *Heritiera minor* can be used as substitutes for hickory. Much interest has been taken and a large number of enquiries received in connection with match-making, owing to the high import duty now imposed on foreign matches. Most of our Indian timbers which have been tried have proved to yield poor quality splints. It is possible that better results may be obtained with these woods by using a slicing instead of a rotary machine.

6. **Section of Wood Preservation.**—The work of years at this subject is now bearing fruit, as the Railways have accepted the use of treated sleepers, while some systems have put up treating plant and other are actively engaged in schemes to do so. The North Western Railway is treating large quantities of sleepers with creosote in open tanks, and has erected a large pressure plant, which should soon be in operation. The Assam Railway Trading Co. has also erected a pressure plant and sleepers are being treated in open tanks in Southern India, while several other Railways have projects on hand to treat their sleepers themselves.

There remains a very important side to this enquiry which has still to be undertaken, and that is to carry out absorption tests and to determine the most economic method of treating the many species of Indian timbers mechanically suitable but deficient in durability unless treated for sleeper work. The experimental pressure plant purchased some years ago by the Forest Research Institute has now been erected, tested and found to answer the purpose admirably. It is so designed that timber can be treated by all well-known methods except the Card Process. The difficulty is that due to financial stringency no Wood Preservation Officer has been appointed, though the results which could be obtained even in a short period of time would certainly be valuable out of all proportion to such an officer's salary. In the meantime provided an Assistant can be appointed, the Forest Economist hopes to run through a little of the most urgent work.

Two records of experiments covering a period of over 10 years were issued during the year, the first Indian Forest Record Vol. IX, Part I, 1922, "Results of the Antiseptic Treatment of Sleepers" and the other Technical Paper No. 231 published by the Railway Board, entitled, "Antiseptic Treatment of Sleepers in India" both reports being by the Forest Economist.

7. **Section of Paper Pulp.**—Mr. W. Raitt was in charge of this section throughout the year and was chiefly engaged in supervising the erection of the complicated experimental pulp plant, with a digester of approximately 15 cwt. capacity and an up-to-date 36 inch experimental paper machine. The necessary crushing and chopping machines are also being installed. The plant is now practically erected, with the exception of the water and steam connections.

At the request of the Bihar and Orissa Government the Officer in charge, Paper Pulp, visited the Cuttack and Angul forests with a view to determining the feasibility of starting a bamboo pulp scheme in that locality. The subject was carefully worked out and a detailed report submitted to the Local Government which indicates a promising commercial proposition.

At the request of the Sirmoor Durbar a local enquiry was made into the pulp making resources of the State and a report presented to the Durbar.

A considerable amount of laboratory work was carried out in connection with bamboo and grasses, which will be of great value when large-scale experiments are started with the new experimental plant now erected on the New Site. A number of routine enquiries were dealt with during the year.

8. **Section of Tans.**—Mr. Pilgrim was in charge throughout the year, and was stationed at Mergui in Lower Burma, to carry out an exhaustive enquiry into the tan-stuffs of the Mangrove forests of that locality. He has now completed the work and is engaged in writing up his report. He also completed a valuable report on the Myrobolams of the Central Provinces and Terminalias of Burma, which have now gone to press. He has also issued a pamphlet during the year on the tanning properties of certain Lagers trœmias in Burma, which appeared in the "Indian Forester."

ZOOLOGY

I.—GENERAL ZOOLOGY AND PHYSICAL ANTHROPOLOGY

BY

N. ANNANDALE, C.I.E., D.Sc., F.A.S.B.,

Director, Zoological Survey of India.

Tours.—The following tours were undertaken by members of the department :—

	Days.
To Southern Shan States from the 1st April to 11th April 1922, Dr. S. L. Hora	11
„ Barkuda, Chilka Lake from 2nd June to 7th June 1922, Dr. S. W. Kemp	6
„ Punjab Salt Range from 24th June to 17th August 1922, Dr. S. L. Hora	55
„ Lucknow from 7th January to 14th January 1923, Dr. N. Annandale	8
„ Barkuda, Chilka Lake, from 19th January to 24th January 1923, Dr. S. L. Hora	6
„ Barkuda from 19th January to 24th January 1923, Dr.N. Annandale	6
„ Buldana, Central Provinces, from 10th February to 25th February, 1923, Mr. H. S. Rao	16
„ Barkuda, Chilka Lake, from 16th February to 20th February 1923, Dr. Baini Prashad	5
„ Barkuda, Chilka Lake, from 16th February to 20th February 1923, Dr. N. Annandale	5
„ Cherrapunji from 15th February to 6th March 1923, Dr. S. L. Hora	20
	138

Publications.—The following publications have been issued during the year :—

" Records of the Indian Museum," Vol. VIII, Part 13.

" Records of the Indian Museum," Vol. XXI, Parts 2—3.

" Records of the Indian Museum," Vol. XXIII, Part 1.

" Records of the Indian Museum," Vol. XXIV, Parts 1—4.

" Records of the Indian Museum," Vol. XXV, Part I.

" Memoirs of the Indian Museum," Vol. V, No. 10.

" Memoirs of the Indian Museum," Vol. VII, No. 4.

Library.—The total additions number 1911. Of this 658 books and parts of periodicals were purchased and the remainder received in exchange and by presentation.

The following additions may be specially mentioned :—

"Handbuch der Biologisch Arbeitsmethoden."

"Journal of Animal Behaviour."

"Psychobiology."

"Journal of Compaarative Psychology."

"Reise in Ostafrika."

"Animaux Venimeus" by Marie Phisalix.

All the above were purchased.

Collections.—As time goes on and the collections increase it becomes more and more difficult to exercise proper supervision over them with the present totally inadequate staff. Discoveries of losses due to petty thefts of spirit and bottles in former years are constantly being made.

Galleries.—I have nothing to add to my report of last year under this heading except to state that the Tibetan collections have been arranged by Mr. J. van Manen, through whose kind assistance many valuable additions have been made in this section. A case containing Brahui musical instruments from Quetta has also been set up.

ZOOLOGY

II.—ECONOMIC ZOOLOGY

Part I.—Agricultural Entomology

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,

Imperial Entomologist.

I.—Work at Pusa.

This has followed on the lines of previous years and a more complete account is given in the Annual Report of the Imperial Entomologist.

Work on the borers of sugarcane and other gramineous plants has been continued but no further novelties were met with. Insect pests of crops have been observed and dealt with as occasion arose. Investigation of life-histories of Indian insects has been continued and their early stages described and figured.

Work on Pathological Entomology has been continued mainly with reference to Veterinary Entomology, with regard to which there appears to be need of a publication dealing with the insect pests of domesticated animals in India and considerable progress has been made in the preparation of a book on these lines. Special attention has been paid to Tabanidæ, from both the systematic and biological aspects, and further work has also been done on the biology of the local Culicidæ. In collaboration with the Imperial Bacteriologist, experiments were commenced at Muktesar on the cyclical transmission of the rinderpest organism.

The usual routine work has been continued with Bees and Lac and in connection with the latter the damage done to the lac crop by *Eublemma amabilis* has been under investigation.

The usual steady progress has been made, as regards the Insect Survey, with the increase, arrangement, and identification of the Pusa collection of Indian Insects, which is now a large and important one, and is increasingly taken advantage of by the Provincial Staffs and other workers on Indian Entomology for the identification of their material.

The second and third parts of the Catalogue of Indian Insects on Culicidæ and Bombylidæ, respectively, have been issued during the year and other parts are under preparation.

The Board having ordered the separate publication of the bibliography heretofore included in this Report, the list of literature on Indian Entomology, prepared for the year 1st July 1920 to 30th June 1921, was extended to 31st December 1921 and issued as Pusa Bulletin No. 139. A similar list of literature for the year 1922 has also been prepared and is now in the press.

II.—Work in the Provinces.

Madras.—The investigation of the bionomics of *Platyedra gossypiella* and *Pempheres affinis* was continued, especially with reference to the checking of the effect of the enforcement of the Pest Act control of the insect pests of Cambodia cotton.

The trial of the control of *Sehœnobius incertellus* (*bipunctifer*) by the method of seedling selection was continued at Samalkota.

An investigation was begun of the bionomics of *Calocoris angustatus* on *Cholam*, especially with reference to control measures.

An investigation of a disease in Betel-vines around Coimbatore—probably due to the attack of the Root-knot Eel-worm (*Heteroderes radicicola*)—was taken up and manurial experiments are under trial towards the control of the disease.

The attack of fruit moths, including three species of *Ophideres*, was investigated in an orchard in Kistna district and remedial measures tried.

A serious attack of *Nephantis serinopa* on coconut at Mangalore was attended to by the combined efforts of the Entomological, Agricultural and Revenue Staff from June 1922 to December 1922. From 1st January 1923, the Pest Act has been brought into operation by Government for eradicating this pest and is being enforced.

Experiments towards the control of the mangohopper were taken up and conducted in certain villages in the Chittoor district but the results have not been as satisfactory as could be desired. It is proposed to repeat them in the coming year.

A fair amount of systematic work was done in Capsids, Braconids, Coccids and Anthomyiads.

Bombay.—Under the Sir Sassoon David Trust Fund investigations were carried out on stem-borers in *juar* at Surat, the borers found being *Chilo simplex*, an Anthomyiad and *Sesamia inferens*. Of these Chilo was found to be the worst pest, attacking up to 50 per cent. of plants, whilst *Sesamia* ranged up to 26 per cent. and in the case of the Anthomyiad the attack was about 15 per cent. in some plots. *Juar* sown at Surat from the middle of July to the middle of August was less attacked by borers in the initial and middle stages of the crop and resisted borer attack better during the ripening stages, in comparison with earlier and latter sowings. No varieties of *juar* were found to be immune from attack. All three borers were found to breed in sprouts from stubble left in the ground, but breeding is stopped if the stubble

is ploughed up and exposed to the sun's heat for about two weeks in the summer, Larvae of *Chilo* are able to survive in *Kabdi* stalks stocked for cattle fodder but are killed by chaffing the stalks. Further trials were made with *Amsacta moorei* by attracting the moths to light-traps on first emergence and by dusting attacked crops with a mixture (1 : 20) of Paris green and lime. Fumigation with carbon disulphide of seeds attacked by beetle pests was also done.

In the Konkan work was done on crabs injurious to the rice crop and on the protection of cruciferous seedlings from flea-beetles.

At Poona some attention was given to the Citrus White-fly (*Aleurocanthus spinifera*) and to *Ophideres* spp., the moths of which attack ripening fruits Work was also done on the parasites of *Chilo simplex*, of which one was found attacking the egg, three the larva and two the pupa.

Central Provinces.—Aleyrodids, particularly on low-growing weeds, are being studied. One Aleyrodid (unidentified), found commonly on *Tephrosea purpurea* (a leguminous weed) was reared up to three generations from 12th July 1922 to 1st October 1922, each generation occupying about 25 days. The female of this insect deposits one small oval egg in a little depression on the leaflet of the weed ; numerous such depressions are seen on one leaflet and thus it presents a very curious appearance.

Work on *Chilo simplex*, the common *Juar* borer, is being continued. During the year six varieties of *Juar* were sown to find out (i) Percentage of attack, (ii) Time and stage of the borer entering the resting period, (iii) Place where a borer rests.

Varieties of *Juar*.	(i) Percentage of Attack.	(iii) Hibernation in larval stage.	
		Stubbles.	Stalks.
1. *Sundia*	67	10	45
2. *Detha*	41	12	65
3. *Saoner*	57	10	72
4. *Lamkansi*	36	13	52
5. *Chapli*	40	13	54
6. *Ramkel*	25	8	49

(ii) Living pupæ were found as late as October, but from November onwards only larvæ were found.

Xanthopimpla nursei so far appears to be a common parasite on *Chilo simplex*. In the laboratory the last emergence of the parasite was in the first week of November and one parasite emerged in May 1923 from larvae obtained from Chhindwara.

Bengal.—During the egg-laying period of the Mango Weevil (*Cryptorrhynchus gravis*) in 1922 careful examination of the mangoes under observation on the Dacca Farm, was made, and the affected trees noted. Besides bagging, plucking of the young fruits with eggs was done, as far as possible, to reduce the pest to a negligible number. Also in 1923 examination of young fruits was done as usual but no fruit was found affected in any stage, although the pest was observed in numbers this year on fruits at Kaorainbazar close to the Dacca Farm, where the fruits are brought for sale from surrounding villages.

A big private mango garden at Dhanbari (Mymensingh), in which the fruits of some trees were formerly attacked by the mango weevil, was also under observation this year. In October and November last the garden was cleared of jungles and the branches killed by borers (*Rhytidodera*) were cut down. The circular areas round the trees were also hoed up. Besides, early in the season when small fruits were formed, a large number of the fruits of previously infested trees and those which fruited early were enclosed in small cloth bags. The exposed mangoes were also under observation from the egg-laying period till the end of the mango season but no fruit was found affected this year. So clean culture and above all consumption of the young fruits of trees detected with eggs on fruits seem to be most essential in keeping off this pest. A note on the pest, with a plate, is being published in the *Bengal Agricultural Journal.*

A serious outbreak of *Agrotis ypsilon* in the Naogaon *ganja mahal* was reported. The place was visited and the cultivators were asked to handpick the caterpillars and irrigate the crop, as a poisoned bait was of no avail. It is gratifying to note the cultivators worked hard to stamp out the pest.

Pulse seeds attacked by pulse beetles (*Bruchus* spp.) were fumigated with carbon bisulphide. A number of termites, ... nests were fumigated with white ant powder.

Assam.—Work on the control of the cutworms (*Agrotis ypsilon*) on the onion crops of South Habiganj was continued with two Andres Maire traps at Khorki and Katora and the results thus far achieved have made a favourable impression on the cultivators.

Rice case-worm, Rice *Hispa*, stem-borers and grass-hoppers were general pests reported from both the Valleys. Army worm caterpillars appeared in the Karimganj Farm but were taken in hand in time and effectively controlled. A serious outbreak of caterpillar pests on Job's tears was reported from the Naga Hills; the Entomological Assistant proceeded to the localities affected and carried on spraying campaigns with considerable success. A Melolonthid beetle grub was reported to have caused heavy damage to the sugarcane crop of the Tezpur Jail. It was inquired into and remedial measures were suggested.

Burma.—Investigation of the paddy showed that borers caused little damage to the main crops; a trial of checking damage to a local *Mayin* crop by late cultivation proved successful.

Baited earthen pot traps proved successful against crabs (*Potamon dayanum*) in paddy fields.

Diacrisia obliqua was the only serious pest of dry-land crops, beans, sesamum, etc.

Investigation of cotton pests showed that early sowing evaded the pests to such an extent that very little damage was done.

Propaganda against the Palm Beetles were undertaken by posters and meetings.

Satisfactory progress was made in sericulture, the number of rearers increasing.

Bihar and Orissa.—Only routine work was carried out up to 31st March 1923 when Entomological Section was closed down.

Punjab.—Particular attention was devoted to the parasites of *Earias insulana* and 13 different species were found and their life-histories worked out. The attack of "Pink bollworm" (*Platyedra gossypiella*) was considerable in some localities (*e.g.*, Sialkot and Ferozpur); a sample of lint and seed from Sialkot weighing 373 tolas contained 370 living caterpillars. Cotton stem borer (*Sphenoptera gossypii*) was quite serious, in some cases 51·5% of the sticks being attacked; removal and subsequent burning of attacked sticks was quite effective.

As a result of the study of stubbles and dead hearts of Sugarcane, Maize and *juar* throughout the Province it has been established (*a*) that *Chilo simplex*, Butl., is mainly found in *juar* and maize, (*b*) that insects damaging sugarcane only are *Diatræa auricilia, Emmalocera sp.*, and *Scirpophaga sp.* The idea of using maize as a trap crop for sugarcane is therefore no longer tenable and the only solution is the safe disposal of the stubbles in which the borers have been seen to hibernate until March. Light trap experiments were continued and the observations on sugarcane moth borers attracted to light recorded.

There has been a serious outbreak of Citrus Psylla (*Euphalerus citri*) and Aleyrodidae (*Dialeurodes citri*) last year. Spraying was quite effective against the Psylla. As regards the Aleyrodidae they can only be killed after three or four operations. Crude oil emulsion or tobacco decoction have been found to be the most effective insecticides.

Mangohopper (*Idiocerusatkinsoni* and *I. clypealis*) were not very serious. The life-history of *I. atkinsoni* was worked out.

For stored grain pests superheating has proved to be a very effective and economical way of "cleaning" insect infested godowns. Experiments on air-tight storage have not so far yielded results of practical utility.

Study of the parasites of crop-pests was continued, and about 31 parasites of different crop-pests were bred in the laboratory. Two species of egg-parasites of *Euproctis fraterna, Mo.* were reared in the laboratory for many generations. Parasites and hyper-parasites of *Euphalerus citri* were observed and the life-cycle of parasites was worked out in detail. During March and

April larvæ and pupæ of *Coccinella punctata* and *Adonia doubledayi*, Muls., were found to be heavily parasitized by small Chalcidids.

Rats were very serious everywhere. Poisoning and fumigation gave satisfactory results. A systematic use of poisoned baits over large areas coupled with co-operation is the best and cheapest means of rat eradication.

North-West Frontier Province.—The Agricultural Station orchards are regularly sprayed, and the fruit growers, now realizing that good fruit cannot be produced without spraying, are showing willingness to spray. The proprietary insecticide called "Katakilla" is still the most satisfactory spray which has been tested at Peshawar. The orchards are not sprayed with it but branches which are affected by aphids or other insects are sprayed.

The olive fruit fly has not yet appeared in the Tarnab grove.

III.—Native States.

Mysore.—The usual campaign against *Kamblihulas* (*Amsacta albistriga*) resulted in the destruction of 270,299 moths representing 135 million caterpillars.

The new remedy devised against the sugarcane borers (*i.e.*, putting out small heaps of cane-trash to trap the moths) has been tested more extensively and with better results than last year.

An interesting principle of control of hard-bodied insects with soft bodied larvae has been found and efforts on the lines suggested by it are now being directed against *Oryctes rhinoceros*. The presence of mercury in a small muslin bag hanging from the lids of jars containing pickles has been found effective against pickle-flies (*Drosophila* sp.).

Other investigations related to Mango-hoppers (*Idiocerus* spp.), Coffee Borer (*Xylotrechus quadripes*), Lime-tree Borer (*Chloridolum alcomene*) and Cotton Boll Worms (*Earias* spp.)

Travancore.—The coconut leaf-roller pest (*Nephantis serinopa*) made its appearance on several trees during the year and extra hands were engaged as fieldmen to induce the owners to cut and burn the affected fronds. On the whole 30,227 trees were so treated and the pest has now practically disappeared from many localities.

There was an outbreak of the rice swarming caterpillar pest [presumably *Spodoptera mauritia*] at Kuttanad, one of the chief rice growing centres of the State; a detailed study of the life-cycle of this pest was made during the year.

The rice stem-borer pest and the ginger borer pest were carefully studied both in the field and in the laboratory. Pests like the rice case worm and rice bug also received attention.

IV.—Other Work.

Indian Tea Association.—Work has been mainly directed to *Helopeltis theivora*, the so-called mosquito-blight of tea, on which the Entomologist has published a very detailed monograph during the year.

ZOOLOGY

II.—ECONOMIC ZOOLOGY

Part II.—Forest Entomology

BY

C. F. C. BEESON, D.Sc., F.E.S., I.F.S.

(1) *Forest Entomologist.*

The year 1922-23 was relatively unfavourable for progress on the biologic and economic sides of forest entomology, owing to the uncertain financial position of the Branch and the indecision as to its future. The writer was absent on four and a half months leave and no technical officer was appointed in the vacancy. In systematics results have been more satisfactory.

Insects of sal.—(*a*) The large heart-wood borer: In Thano forest near Dehra Dun the separate enumeration of sal trees attacked by *Hoplocerambyx spinicornis* has been continued with a yield of 4,411 for the season 1922-23. This quantity represents the recognisable portion of the attack of 1922 plus the over-looked portion of the attack of 1921. As the markings must be carried out at the end of the rains, when the attack is not fully developed, some of the less heavily attacked trees are not detected, until after their death in the following year. The annual yields obtained since 1916-17 are as follows :—6,772 ; 10,190 ; 23,545 ; *nil* ; 3,855 ; 5,821 ; 4,411. As these figures do not represent the actual annual attack an attempt has been made to arrive at the correct values ; these appear to be 8,000 for 1920, 4,000 for 1921 and 2,500 for 1922. In the period 1920-21 control measures were instituted, the effect of which would first be visible in the attack of 1921. Since the rainfall has annually been increasing since 1919 it is believed that its effect has been counteracted by the remedial measures, and that the epidemic is now completely under control.

An attempt to estimate the financial loss due to the attacks of the borer has not been successful owing to the great fluctuations in the prices realised at timber auctions for clean and damaged timber, and absence of any basis for comparison. Moreover it does not seem possible to arrive at an idea of the sylvicultural damage, although a revision of the working plan is in progress.

The Thano borer outbreak illustrates very aptly the present position of forest insect control in India. The entomological side of the problem starts

with the application of general principles based on the forest entomology of Europe and North America, which soon give place to new conceptions arising from acquaintance with local conditions. The control measures suggested are mainly theoretical, and, as they necessarily involve extraordinary expenditure or departure from routine, are adopted by the departmental executive with reluctance. If applied thoroughly the results are measurable with great difficulty, and, finally, if the control measures can be demonstrated as successful, the cost of application and the value of the damage prevented cannot be calculated.

(*b*) In the laboratory and insectary experiments were conducted on the emergence period of the borer and length of life, etc., under varying conditions of temperature and humidity. Owing to the absence of the Forest Entomologist and the employment of the Upper Grade Assistants on educational work the results were unsatisfactory.

(*c*) A survey of the borers of sal with reference to their geographical distribution and alternate food-trees was made. In the families Scolytidae, Platypodidæ, Curculionidæ, Brenthidæ, Anthribidæ, Bostrychidæ and Longicornia over sixty species are identified as sal borers, of these 45% occur also in the Malay Archipelago, 60% in Indo-China, 100% in Assam and Bengal, 85% in the submontane region of the United Provinces, 57% in Central India, 38% in South India and Ceylon, while 27% are extra-oriental. These results are sufficient to show that the study of the borers of *Shorea robusta* cannot be restricted to conditions in the sal habitat, but involves other forest types and timber species elsewhere in British India. Very few species are confined to sal, or to parts of its habitat, and these monophagous species are not necessarily important as pests. The composition of the borer-fauna at any part of its habitat is a function of the locality, *i.e.*, the ecological conditions of the environment are of greater importance in deciding what species of borers occur than in the presence of sal as a food-supply.

Insects of Teak.—Teak insects have received no attention during the year. The special investigation of the beehole borer carried on by Mr. J. M. D. Mackenzie was concluded by his departure on six months leave, and by the decision of the Government of Burma not to re-open the enquiry. The chief results obtained from the enquiry are :—(1) the abundance of the pest varies greatly in neighbouring areas and in successive years ; (2) natural control factors periodically bring the local annual incidence almost to zero, but on the whole the mean annual incidence slowly increases ; (3) the increase is relatively greater in the past 20-30 years in both plantations and natural forest, but there are indications of a general decrease quite recently.

No explanations of universal application can be given for the fluctuation in abundance, and, in particular, the correlation of fire-protection with the conditions mentioned in (3) is neither proved nor disproved. The sylvicultural schemes providing for early and frequent thinnings in plantations, etc., afford a means of producing periodic reductions in the abundance of the pest, and there is reason to believe that large clearances for regeneration can be utilised to afford a heavy initial check.

Future investigations should determine the comparative effect of thinnings, the possibility of retarding the infestation of concentrated regeneration areas, the value of alternate hosts as trap-crops and the effect of fires. The value of the work already done on this pest is much invalidated by the absence of reliable historical records for the forests sampled, and we are therefore compelled to wait for the future to supply accurate histories. Until a wholetime investigator is available to maintain continuous observations no progress can be anticipated. Meanwhile some thousands of acres of teak regeneration are being formed annually in which the pest is establishing itself with far greater rapidity than it did in the nineteenth century.

Miscellaneous pests.—*The Borers of timber under seasoning.* Work on this subject was continued in the Insectary, with special attention to dry wood borers of the type of *Stromatium barbatum.* About 9,000 specimens of insects were reared in the Insectary.

(2) *Systematic Entomology.*

The Insect Collection.—The growth of the collection of forest insects during the year excelled previous records. A total of 752 species not previously represented was added, including 26 novelties that are represented either by types or by cotypes. Nearly 16,000 specimens were mounted and labelled, of which 6,235 specimens were sent abroad to specialists for determination. The entomologists who have given their services on behalf of the Institute are Drs. Arrow, Blair, Marshall and Obenberger, Messrs. Andrews and Champion, Mons. Fleutiaux, Desbordes and Lesne, Herrn Kleine, Corporaal, and Col. Winn Sampson for *Coleoptera ;* Dr. Waterston, Messrs. Crawley and Turner and Rev. Morice for *Hymenoptera ;* Messrs. Tothill and Senior-White, and Miss Ricardo for *Diptera ;* M. Esben-Petersen for *Neuroptera ;* Prof. Silvestri for *Isoptera ;* Major Fraser for *Odonata ;* Messrs. Fletcher, Meyrick and Tams for *Lepidoptera ;* Mr. Green for *Homoptera.*

Dr. Cameron has worked especially at the revision and expansion of the following families :—*Staphylinidæ, Erotylidæ, Endomychidæ, Cloydiidæ, Elateridæ, Tenebrionidæ, Brenthidæ, Nymphalidæ, Papilionidæ, Pieridæ,* and *Chalcidæ ;* Dr. Beeson has dealt with the *Scolytidæ, Platypodidæ* and *Bostrychidæ ;* Babu Soilendra Nath Chatterjee has been mainly responsible for the revision of the *Rhopalocera.* In all over 12,000 specimens of identified insects have been added to the collection in the last twelve months. Exchange of material has been effected between the Institute and foreign entomologists, and other scientific institutions in India, Europe and America.

For the accommodation of the growing collection ten 20-drawer store-cabinets and 227 store-boxes were obtained—a very inadequate equipment due to the rigorously enforced economy in new stores.

General Review of Systematic Work.—Advance on the systematic side of forest entomology during the last two years has been the most satisfactory feature of research, but progress has received a serious check by

the breakdown in health of Dr. Cameron necessitating his departure from India at the close of the year under review.

Dr. Cameron commenced work on 4th December 1920. During the two and a quarter years that systematics have received adequate attention 1,786 new species have been acquired (as against 190 species in the previous three years, 1917-1920), and about 25,000 specimens have been named and incorporated.

VETERINARY SCIENCE

BY

J. T. EDWARDS,

Director, Imperial Bacteriological (Veterinary) Laboratory, Muktesar.

I.—Imperial Bacteriological Laboratory, Muktesar.

Rinderpest.—As this represents the most serious single disease condition in animals in India the problem of its origin, nature, and immunology was attacked on a large scale, and the available resources of the laboratory were devoted mainly to its intensive study. Results of far-reaching importance were obtained concerning the properties of the virus, its probable nature, transmissibility to experimental animals (notably the rabbit, by blood "passage,") and the effects of exaltation and attenuation. Numerous experiments were conducted upon methods of anti-serum production. Work upon this disease is still in active progress and it is not proposed to make definitive announcements until the results already obtained have been confirmed and elaborated, when the records will be collected in the form of a memoir for publication.

Haemorrhagic septicaemia of Cattle.—Systematic observations and experimental tests undertaken on the larger animals furnished evidence upon the efficacy of the biological products (vaccines and sera) now issued from the laboratory for preventive treatment in the field. Further work in this direction is in progress. The results are reassuring, in view of the discredit that appeared to have been thrown by certain American workers upon vaccine treatment as the outcome of experimental tests upon small laboratory animals.

Contagious abortion in mares and cows.—Agglutination tests were performed systematically at the laboratory upon sera obtained from important breeding studs in the Punjab with a view to obtaining evidence regarding the incidence of the common form of equine contagious abortion, and the possibility of arresting the spread of the disease by the segregation of carriers. Attempts were made at the laboratory to evolve a satisfactory method of vaccination. The economically most important disease of breeding cattle in Western Countries—contagious abortion—was detected in certain large Government dairy herds in India, measures were taken for the systematic testing of these herds to determine the incidence of the disease and arrangements were made to control its spread by segregation methods or by vaccination.

Mange.—Observations were made upon the life-history of the sarcopt of the buffalo, and the vulnerability of the various stages in its development with a view to obtaining knowledge upon a satisfactory system of acaricidal treatment. (A paper was read by Mr. T. M. Timoney, 3rd Bactoriologist, upon this subject at the 5th Entomological Conference held at Pusa in February 1923.)

East Coast Fever.—In the course of routine examinations for protozoan parasites at the laboratory six cases of infection in cattle with a parasite quite indistinguishable morphologically and in distribution in the tissues from *Theileria parva*, the causal agent of the formidable East Coast fever of cattle in Africa, were encountered within a period of one month (June-July 1922). The parasites did not appear to have caused any grave disorder, and attempts to transit them to susceptible animals failed.

Other bovine piroplasmosis.—Extremely numerous infections with *Theileria* (*Gonderia*) *mutans* were discovered, notably in smears taken from cattle after infection with rinderpest, and sometimes this parasite appeared capable *per se* of setting up serious, even fatal, disease. *Piroplasma* (*Babesia*) *bigeminum* was frequently detected.

Bovine coccidiosis.—Numerous cases of this affection were detected in cattle at the laboratory ; in fact, after the application of the finer methods of diagnosis it was difficult to obtain cattle which were not carriers of coccidia. It has been ascertained in other countries that resuscitation in virulency of this latent infection may prove a serious complication during the progress of an outbreak of rinderpest. It would appear that this phenomenon prevails in India to an extent hitherto unsuspected.

Trypanosomiasis.—Systematic attempts were made to discover a cheap, easily applicable and efficacious treatment of surra. It was found that in the more resistant host species such as cattle and buffaloes infection could be temporarily suppressed very readily by means of tartar emetic. In the more susceptible species such as the horse, a few tests indicated that intensive administration of a potent arsenical compound, tryparsamide, reported to be efficacious even in the treatment of human sleeping sickness (kindly supplied to the laboratory by the Rockefeller Institute), did not check the progress of the disease to such an extent that fatalities were suppressed.

"Nasal granuloma" of cattle.—Morbid specimens of this condition were received from Assam, Bihar and Orissa, and the Bombay Presidency; the peculiar granular formations resembling "actinomyces" granules were detected in the lesions, and attempts were made to elucidate their nature.

Strangles.—The possibility of controlling this affection among horses at Army Remount Depôts was studied, and sero-vaccination undertaken systematically at certain depôts. This work will have to be continued for some time to come in order to obtain satisfactory information with regard to the value of the treatment.

Diseases of young stock.—The organisms responsible for certain affections ("joint-ill," "naval-ill," diarrhoea, and early mortality) among foals,

particularly, in certain parts of India were studied. Among various organisms isolated may be mentioned a strain which was found to be indistinguishable from *Bacillus viscosum-equi*, the common cause of pyaemic nephritis of foals in Europe.

A number of experimental tests was made upon material received from an enzootic pleuro-pneumonia of young sheep in Madras.

A considerable number of interesting specimens of minor interest was studied, and advice tendered to officers of the R. A. V. C. and I. V. S. on technical problems.

Systematic training of officers of the Provincial grade of the I. V. S. selected for promotion to Imperial rank (two years' course) and of officers of the R. A. V. C. and I. V. S. (short summer courses) was given in the methods of animal disease investigation.

II.—Camel specialist, Sohawa, Punjab.

(*a*) It is claimed that investigations upon the treatment of surra in camels by means of tartar emetic have demonstrated conclusively the efficacy of this drug as a curative agent. Treatment has been carried out on a large scale by the military authorities in India and Aden with very satisfactory results, according to the reports received from officers of the R. A. V. C. This has resulted in a saving to Government amounting to several lakhs of rupees during the financial year.

(*b*) Transmission of surra by different varieties of biting flies was demonstrated and by a newly discovered species of tick *Ornithodorus crossii* Brumpt. The discovery of the transmissibility of trypanosomiasis by means of ticks is of great interest, for it is quite possible that human trypanosomiasis (sleeping sickness) in Africa may be transmitted in the same manner.

(*c*) The fly *Hypoderma crossii* Patton, the cause of "warbled" hides in goats, was bred out and methods suggested to reduce the damage caused by this fly. The economic loss caused by the damage to hides is very great: a firm of hide importers in England reported that one-fourth of the hides from Karachi were damaged to the extent of 60 to 70 per cent. of their value. Many thousands of goats and cattle from Pindi to Delhi were examined and the percentage of cattle found infected was very high. On the other hand, infection was only detected in goats maintained in hilly districts, whilst cattle were found infected both in hilly districts and on the plains. In England the loss caused by the warble flies to dairy cattle has been calculated at £3 per head. The loss caused by the fly in Punjab must therefore be enormous in view of the number of cattle and goats kept, when account is taken both of the damage to the hides of these animals and the deterioration in productive value of the dairy cattle.

(*d*) A survey of the biting flies and other arthropods of the Punjab is being undertaken. This has resulted in the discovery of

(*i*) the fly *Hypoderma crossii* Patton causing warbles in goats,

(*ii*) a new species of tick *Ornithodorous crossii* Brumpt,

(*iii*) a new species of "bot" fly, hitherto unnamed, bred from the nasal cavities of the oorial (wild sheep).

Tabanus suflies Jaenaeke and *Ornithodorus savignyi* have been identified for the first time in the Punjab, and a large number of new species of Tabanidæ (hitherto unnamed) has been collected.

(*e*) It was ascertained that heavy losses occurred during the year amongst poultry from spirochaetosis. These losses might have been reduced by 95 per cent. if the owners had adopted the treatment recommended.

(*f*) Heavy losses in animals due to surra occurred during the year along the Deg Nalla. This area is probably the worst affected zone in the Punjab.

III.—Punjab Veterinary College, Lahore.

(*a*) Prophylactic inoculation against rabies in dogs has now been undertaken successfully for the past eight years by Mr. Taylor, Professor of Pathology, and the results obtained warrant the conclusion that the method employed may now be safely applied in general practice. Out of 321 dogs treated in this manner at the Hospital, 13 developed rabies during the progress of the treatment and only 7, or 2·3 per cent., developed rabies subsequent to the completion of the treatment.

(*b*) Experimental work was undertaken upon canine surra and as the results were encouraging it is proposed to continue the work during the next cold weather.

(*c*) Some experimental tests upon the so-called "deficiency" diseases were carried out by Captain Sewell upon horses, pigeons, and rabbits. The results are promising and further work in this direction is in progress.

(*d*) During the past two years S. Hardit Singh has been engaged in preparing dissection specimens for the anatomical museum, and sixty-one specimens have already been mounted.

IV.—Government Cattle Farm, Hissar, Punjab.

The following scientific publications were prepared during the year :—

(*a*) A note on Haemorrhagic Septicaemia, by R. Branford, M.R.C.V.S., to be published as a leaflet by the Director of Agriculture, Punjab.

(*b*) A note on Ensilage made from Sheesham leaves, by Captain Sewell, M.R.C.V.S., published in the now defuct *Industrial Bulletin*.

(*c*) A note on Johne's Disease, by Captain Sewell, published in the *Agricultural Journal of India*, Vol. XVII.

V.—Madras Veterinary College.

(*a*) Investigations were conducted on the disease conditions known as Nasal Granuloma and Infectious Lymphangitis affecting cattle in the Presi-

dency. These investigations formed the subject matter of two papers read by M. R. Ry. V. Krishnamurthy Ayyar Avergal, Professor of Pathology in the College, at the Second Veterinary Conference held at Calcutta in February 1923. Abstracts of these papers are being published as appendices to the Report of the Proceedings of the Conference.

(*b*) Work was carried out upon the preventive inoculation of dogs against rabies, in collaboration with Colonel Cornwall, of the Pasteur Institute, Conoor.

(*c*) A systematic collection and classification of worm parasites and flies affecting animals in the Presidency was attempted. It is of interest to find that the fly *Cobboldia elephantis* exists in Southern India, and its identification was confirmed by the Imperial Entomologist.

VI.—Bombay Veterinary College.

Specimens (smears and sections of lung) received from a cow that had succumbed at Nasik, in October 1922, disclosed conclusive evidence of infection with advanced bovine tuberculosis. This case is of particular interest as it represents what appears to be the first record of a condition occurring in Bombay Presidency indistinguishable from bovine tuberculosis as it is known to occur elsewhere. (*Vide* Bovine Tuberculosis in the Bombay Presidency by M. H. Sowerby, I.C.V.D., *Indian Journal of Medical Research*, 1923, April, Vol. 10, No. 4, pages 1169—1171.)

VII.—Miscellaneous.

Information from the Provinces shows that elsewhere the efforts of the veterinary staffs were not specially diverted to scientific research. Much valuable knowledge is, however, to be obtained from the records of observation and treatment of animal disease in the field in the Annual Reports of the several Provinces. The Veterinary Adviser to Government, Central Provinces, calls attention to the information contained in the proof-copy of his Annual Report for the year under report. It is of considerable interest to note that the most serious epizootic disease of cattle in India, rinderpest, displayed remarkably low virulence during the year and showed little tendency to spread from the few centres in which it appeared. An instructive chart is published in the report illustrating the seasonal incidence of the more serious epizootics: it is of considerable interest to note that rinderpest and foot and mouth disease display their highest degrees of severity at opposite seasons of the year. The reported incidence of anthrax, over 2,000 cases, was high, but it is admitted that it represents only a relatively low proportion of the total incidence. Much valuable information was obtained by systematic examination of a large number of blood smears and other morbid material.

MEDICAL RESEARCH

BY

The Hon'ble Major-General R. CHARLES MacWATT, C.I.E., M.B., F.R.C.S., K.H.S., I.M.S.,

Director-General, Indian Medical Service.

The following is an extract from the Annual Report of the Scientific Advisory Board of the Indian Research Fund Association for the year 1922-23.

* * * * * * *

Leprosy.—Dr. E. Muir summarises progress as follows :—

1. Encouraging results have been obtained in treatment with the ethyl ester of various fatty acids, especially with those derived from the oils of certain trees—notably Chaulmoogra and hydnocarpus oils.
2. The effect of these esters in treatment is being compared with that of linseed ester.
3. Experiments have led to the elimination of the irritating property of the esters, so that administration is now accompanied with a minimum of pain.
4. The efficacy of various other drugs and vaccines in treatment has been tested.
5. An attempt to infect laboratory animals with leprosy has so far met with no success.
6. A histological examination of the various lesions found in leprosy has been made.
7. An investigation is being made into the ferment responsible for the breaking of bacilli in the tissues which takes place under treatment and also spontaneously under certain circumstances.
8. The reason for the positive Wasserman reaction in so many cases of leprosy is under enquiry.
9. The relative infectiousness of pauper and non-pauper lepers is being examined with a view to ascertain the possibility of elimination of spread of infection by compulsory segregation of pauper lepers.

In connection with the above, valuable results have been obtained by Dr. Nishi Kanta De, who is working in the chemistry of drugs used in treatment and of the blood of lepers and resistant animals.

* * * * * * *

Cancer.—Dr. K. K. Chatterji continued his examination of the efficacy of Margosate Oil and its derivatives in treatment.

Influenza.—Major King, I.M.S., examined statistically the records of vaccinations against Influenza, and found the evidence relating to its efficacy to be inconclusive.

Pneumonia.—Captain Malone, I.M.S., with the co-operation of the Military Authorities conducted in Quetta a further trial into the efficacy of anti-pneumococcic vaccine. The results are being examined statistically.

Captain Malone also tested the efficacy of a therapeutic vaccine in the treatment of cases, and grouped, according to type, the pneumococcic isolated from patients.

Deficiency Diseases.—In addition to very valuable work in connexion with the histology and pathology of these diseases Lt.-Colonel McCarrison, C.I.E., I.M.S., has been experimenting in collaboration with the Agricultural Chemist, Madras, on the vitamin value of 12 different samples of rice grown under known conditions of soil and manurage, and on the value of ragi grown by the Agricultural Department on experimental plots of known composition and manurage.

Other experiments in progress are :—

(*a*) The Nutrition value of Dal as a substitute for meat.

(*b*) The types of disease resulting from the too exclusive use of various rices commonly eaten in India.

(*c*) The effect of the development of certain toxins in rice during storage.

Revision of Indian Culicidae.—Captain Barraud has completed eight papers for publication, and in them has described many species new to science. When work on all the genera is finished the complete revision will prove of inestimable value to future workers in mosquito-borne diseases.

Kala-Azar.—Work has been carried out on the following lines :—

(*a*) Treatment of cases in the special research hospital. Promising results have been obtained.

(*b*) Investigation into the method of transmission of infection. The main heads of this branch of the enquiry are :—

(1) An entomological survey of infected and uninfected areas.

(2) The examination of various insects with a view to the discovery of definite stages in development after injection of the parasite.

(3) The examination by cultural methods of wild specimens of the bed bug to see if such specimens ever contain living forms of the parasite.

(4) Transmission of the disease to laboratory animals.

(5) Examination of excreta of human patients to ascertain if the parasite ever leaves the human body therein. Major Shortt, I.M.S., has succeeded in proving that the living parasite is in some cases contained in the urine.

* * * * * * *

In connexion with the work in Assam Mr. C. M. Hutchinson, C.I.E., is preparing specimens showing the normal cytology of insects :—an obvious preliminary to the study of pathological conditions.

Dr. Brahmachari continued his research into the chemotherapy of antimonial compounds used in treatment of Kala-Azar. His preparations are tested in the research hospital, Shillong. With one, Urea Stibamine, very promising results were at first obtained.

Malaria.—Major J. A. Sinton, V.C., O.B.E., I.M.S., investigated the action of quinine in treatment. By administering the drug in combination with alkali he has brought forward evidence that a comparatively small amount of quinine is sufficient to cure the paroxysm. He is now investigating the comparative liability of persons so treated to relapses.

Major H. W. Acton, I.M.S., continued his researches into the efficacy of cinchona alkaloids and compounds in treatment.

The Reverend Father Caius was engaged in the chemical analysis of quinine and cinchona alkaloids.

Ankylostomiasis.—The enquiry under Dr. K. S. Mhaskar in co-operation with the Reverend Father Caius terminated on 27th January 1923. Further work in relation to the diagnosis of hook-worm infection is being carried out at the King Institute of Preventive Medicine, Guindy.

* * * * * * *

Lathyrism.—The three aspects of this enquiry, chemical, botanical and pharmacological are being investigated in co-ordination by Dr. J. L. Simonsen of the Forest Research Institute, Mr. A. Howard, Imperial Economic Botanist and Captain L. A. P. Anderson, I.M.S., at the Central Research Institute, Kasauli.

Results have been obtained which promise to solve the cause of the disease and lead to the introduction of simple methods for its prevention.

Antivenin.—The Reverend Father Caius continued this enquiry, which has for its object the concentration of the serum in order to over-come to disadvantages attaching to a bulky dose.

Composition of the River Waters in Bengal.—Work was continued by Rao Sahib Govinda Raju throughout the year on the lines reported last year.

* * * * * * *

Entomological Section of the Central Research Institute, Kasauli.—As stated last year the cost of this section was borne by the Indian Research Fund Association for the year under report.

The training of Sub-Assistant Surgeons and laboratory attendants was continued during this year under and at the cost of the Indian Research Fund Association.

Indian Journal of Medical Research.—This Journal has just completed its 10th year of existence.

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INDEX.

A

	PAGE.
Afforestation, experiments on	43
Air, upper, investigation of	10
Aleurites Montana oil, study of	7
Animal nutrition, work on	5
Ankylostomiasis inquiry	70
Antiseptic treatment of sleepers, results of, work on	50
Antivenin inquiry	70
Astronomy	8

B

Bacteriological work in various provinces	41
Bacteriology, agricultural	36
Bamboo regeneration, experiments on	44
Borers of timber under seasoning, work on	61
Bosswellia serrata gum oleo-resin, industry of	49
Botanical Survey	19
Botany, economic, agricultural	31
,, ,, Cinchona cultivation in Burma	22
,, ,, forest	29
,, systematic in various provinces, work on	19
Bovine coccidiosis, work on	64
,, piroplasmosis, work on	64
Burma beans, work on	4

C

Camel diseases, work on	65
Cancer research	69
Cardamons, work	4
Cellulose producing alcohol, experiments on	5
Chemistry, agricultural	1
,, forest	6
Coconut palm, an account of	27
Contagious abortion in mares and cows, work on	63
Cotton, economic enquiries relating to	26
Cymbopogon martini, production of "Rosha oil" from	49

D

	PAGE.
Dalbergia Sissoo, pathological condition of	30
Deficiency Diseases inquiry	69
Diseases of young stock, work on	64

E

East Coast fever, work on	64
Eclipse expedition to Australia	9
Economic enquiries, geological	14
Eleusine coracana, feeding tests with	4
Entomology, agricultural, economic	53
,, ,, work at Pusa	53
,, ,, ,, in Assam	56
,, ,, ,, ,, Bengal	56
,, ,, ,, ,, Behar and Orissa	57
,, ,, ,, ,, Bombay	54
,, ,, ,, ,, Burma	56
,, ,, ,, ,, C. P.	55
,, ,, ,, ,, Madras	54
,, ,, ,, ,, Mysore	58
,, ,, ,, ,, N. W. F. Provinces	58
,, ,, ,, ,, Punjab	57
,, ,, ,, ,, Travancore	58
,, ,, ,, of Tea Association	58
,, forest	59
,, systematic work concerning	61
Essential oils of various Indian species, work on	6

F

Fixed oil, work on	7
Forest Botany, systematic, work on	29
,, Products, economic	45

G

Gardenia, Chemical investigation of	7
Geodesy	16
Geology	14
Green manuring, experiments in	38

H

Hæmorrhagic septicæmia, work on	

I

	PAGE.
Indian Culicidae, revision of	69
Indigo, bacteriology of	39
Influenza, examination of the records of vaccinations against	69
Insect, collection of	61
Ipecacuanha in Burma, cultivation of	24

J

Juar, malting value of	5

K

Kala-Azar inquiry	69

L

Lathyrism inquiry	70
Leprosy, work concerning	68
Levelling operations in various provinces	16—18

M

Magnetic Survey	12
,, ,, observations at Repeat stations	12
,, ,, special observations during total eclipse	12
Malaria, work concerning	70
Mange, work on	64
Manures, availability of	3
,, green, residual effect of	2
,, farmyard, preparation of	2
,, field experiment with	2
,, nitrogenous, work on	3
,, organic, work on	2
,, phosphatic, work on	3
Meteorites	14
Meteorology, general	10
Mineral phosphates, solubilization of	39
Mycological work in Assam	35
,, ,, ,, Bengal	34
,, ,, ,, Bombay	33
,, ,, ,, Central Provinces	34
,, ,, ,, Madras	32
,, ,, ,, United Provinces	35
,, ,, of Indian Tea Association	35

N

PAGE.

"Nasal granuloma" of cattle, work on 64
Nitrification of cattle urine, activation of 34
Nitrogen fixation, effect of phosphates and sulphur upon 38
„ „ in soil 36

O

Oil seeds, work on 3
Opium, results of experiments with 4
Orange cultivation in Burma 28
Organic residues, bacterial decomposition of 30

P

Palæontology 14
Paper pulp industry, development of 50
Plant physiology in agriculture 27
Pneumonia inquiry 69
Publications, botanical survey 24

R

Rice, inheritance of character in 27
„ sclerotial disease of 31
„ work on 4
Rinderpest, work on 63
River water in Bengal, composition of work on 70

S

Sal, insect pest of, work on 59
„ oecology of, work on 29
Salvia plebeia, oil from, study of 7
Seasoning, of timber, experimental work on 46
Shellac, chemical investigation of 7
Shorea robusta, regeneration of 43
Silviculture 42
„ experimental, work on 43
Soil nitrogen, work on 1
Soils, chemical survey of 1
„ Hydrogen Ion concentration of 2
„ mechanical analysis of 1
„ saline and acid, work on 1
Solar physics—work at Kodaikanal 8

PAGE.

Spectroscopic research 8
Statistical work in Silviculture 42
Strangles, work on 64
Sugarcane, economic enquiries relating to 26
„ in various provinces, work on 3
„ refractometric method of testing 3
„ windrowing experiments with 4
Sugar Mills, bacterial infection of 40

T

Tamarinda as a source of tartaric acid and alcohol 7
Tan-stuffs, inquiry into 50
Tea, factors influencing quality of 4
Teak, insect pest of, work on 60
Terminalia Chebula, tanning value of, inquiry into 30
Terrestrial magnetism, work on 12
Tidal operations 16
Timber testing 47
Trypanosomiasis, work on 64

W

Water hyacinth, report on. 27
Wheats of Bihar and Orissa, study of 27
Wood preservation, work on 50
„ technology 46
„ utilisation 49

V

Veterinary Science 63

Z

Zoological Survey, collections 52
„ „ departmental tours 51
„ „ galleries, condition of 52
„ „ library work 52
„ „ publications of the year 51

Departmental Publications.

I.—Meteorological Department—

Government of India Office.

(1) The Indian Daily Weather Report and Chart.
(2) The Weekly Rainfall Summary.
(3) The Monthly Weather Review.
(4) The Annual Summary.
(5) The Rainfall of India.
(6) Indian Meteorological Memoirs.

Bengal Office.

(1) Bengal Daily Weather Report and Chart.
(2) Monthly Rainfall Tables and Summaries of the chief feature of the weather of the month over Bengal.

Bombay Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

Madras Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly Rainfall Tables (*Madras Gazette*).

Allahabad Office.

(1) Monthly Weather Summaries (*United Provinces Gazette*).
(2) Annual Summary.
(3) Monthly Rainfall Tables (*United Provinces Gazette*).

Lahore (Simla) Office.

(1) Monthly Summary } of Punjab weather.
(2) Annual Summary }

II.—Geological Survey. ...

The publications of the Department include—

Palæontologia-Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XLV, including the larger papers on geological subjects.

Records, Vols. I—L, including the shorter papers and Annual Reports from 1868 to 1915 sold in parts, priced one rupee each.

Manual, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta.

Indexes to the Genera and Species described in the *Palæontologia Indica* up to 1891, to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

III.—Survey of India.

(1) Annual General Report.
(2) Professional Papers.

IV.—Botanical Survey and Royal Botanic Garden, Calcutta.

(1) Annual Report of the Botanical Survey of India.
(2) Records of the Botanical Survey, Vols. I—X.
(3) Annual Report of the Industrial Section, Indian Museum.

(4) Annual Report of the Royal Botanic Garden, Calcutta.

(5) Annals of the Royal Botanic Garden, Calcutta, Vols. I—XII, Part II.

A list of the contents of the Records and of the Annals with prices of the numbers and volumes still available can be obtained by applying to the Superintendent, Royal Botanic Garden, Calcutta.

V.—Department of Agriculture.

(1) Annual Report.—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology, and the like).

(2) The Agricultural Journal of India.—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in agriculture.

(3) Scientific Memoirs of the Department of Agriculture.—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological, and the like.

(4) Bulletin.—An occasional publication containing information on agricultural matters of a temporary nature.

(5) Leaflets.—Short notes of practical instruction in agricultural matters, dealing mainly with Entomological subjects.

VI.—Forest Department.

(1) Review of Forest Administration in British India by the Inspector-General of Forests (issued annually).

(2) Annual Progress Report of Forest Administration in each Province.—Issued by the Local Governments annually.

(3) Indian Forest Records.

(4) Indian Forest Memoirs.

(5) The Indian Forester.—A monthly Journal of Foresty, Agriculture, Shikar and Travel. This is a Departmental Journal, Published monthly.

(6) Bulletins are published from time to time.

VII.—Zoological Department.

(1) The Annual Report, 8vo.

(2) Records of the Indian Museum, 8vo. Containing short papers on Indian Zoology. One or two volumes issued annually in quarterly parts.

(3) The Memoirs of the Indian Museum, 4to. Containing monographs and other important papers. Published at irregular intervals.

(4) Descriptive Catalogue of Indian Decapod Crustacea, 4to. Parts published at irregular intervals.

(5) Descriptive Catalogue of Indian Echinodermata, 4to. Parts published at irregular intervals.

VIII.—Civil Veterinary Department.

(1) Annual Report.

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